

УДК 547.42:537.226.1/2

А.Ф. Тодрин*, Е.В. Тимофеева

Термофизические свойства криопротекторов.**VIII. Диэлектрическая проницаемость ряда криопротекторов, их водных растворов и смесей**

UDC 547.42:537.226.1/2

A.F. Todrin*, E.V. Timofeyeva

**Thermophysical Properties of Cryoprotectants.
VIII. Dielectric Permeability of Some Cryoprotectants,
Their Aqueous Solutions and Mixtures**

Реферат: Систематизированы литературные данные по статической диэлектрической проницаемости воды, чистых криопротекторов, их водных растворов и смесей. Построены эмпирические полиномиальные уравнения для расчета статической диэлектрической проницаемости воды и чистых криопротекторов в зависимости от температуры. Для водных растворов и смесей некоторых криопротекторов получены эмпирические полиномиальные уравнения в зависимости от температуры при фиксированных концентрациях или от концентрации при фиксированных температурах.

Ключевые слова: криопротектор, статическая диэлектрическая проницаемость, эмпирические полиномиальные уравнения.

Реферат: Систематизовано літературні дані зі статичної діелектричної проникності води, чистих криопротекторів, їх водних розчинів і сумішей. Побудовано емпіричні поліноміальні рівняння для розрахунку статичної діелектричної проникності води і чистих криопротекторів в залежності від температури. Для водних розчинів і сумішей деяких криопротекторів отримано емпіричні поліноміальні рівняння в залежності від температури при фіксованих концентраціях або від концентрації при фіксованих температурах.

Ключові слова: криопротектор, статична діелектрична проникність, емпіричні поліноміальні рівняння.

Abstract: There were summarised the reported data on static dielectric permeability for water, pure cryoprotectants, their aqueous solutions and mixtures. The empirical polynomial equations to calculate static dielectric permeability for water and pure cryoprotectants depending on temperature were derived. The empirical polynomial equations for aqueous solutions and mixtures of some cryoprotectants depending on either the temperature at fixed concentrations or the concentration at fixed temperatures were obtained.

Key words: cryoprotectant, static dielectric permeability, empirical polynomial equations.

Диэлектрическая проницаемость – физическая величина, которая характеризует свойства изолирующей (диэлектрической) среды и показывает зависимость электрической индукции от напряженности электрического поля. Она определяется эффектом поляризации диэлектриков под действием электрического поля и величиной диэлектрической восприимчивости среды.

Любая среда уменьшает напряженность электрического поля по сравнению с вакуумом. Диэлектрическая проницаемость показывает, во сколько раз электрическое поле в диэлектрике меньше электрического поля в вакууме, и дает возможность судить об интенсивности процессов

Dielectric permeability is the physical quantity, characterizing properties of isolating (dielectric) medium and demonstrating the dependency of dielectric flux density on electric field intensity. It is determined by the polarization effect of dielectrics under the impact of electric field and by characterizing this effect value of dielectric susceptibility of medium.

Any medium reduces the electric field intensity if compared to the vacuum. Dielectric permeability shows in which extent a electric field in a dielectrics is lower than in the vacuum and enables judging about the intensity of polarization processes and the quality of dielectric. The dielectric polarization is determined by the total effect of different polarization mechanisms.

Отдел низкотемпературного консервирования, Институт проблем криобиологии и криомедицины НАН Украины, г. Харьков

***Автор, которому необходимо направлять корреспонденцию:**
ул. Переяславская, 23, г. Харьков, Украина 61015;
тел.: (+38 057) 373-38-71, факс: (+38 057) 373-30-84,
электронная почта: todrin@mail.ru

Поступила 16.09.2014
Принята в печать 02.10.2014

Проблемы криобиологии и криомедицины. – 2015. – Т. 25, №1. – С. 131–150.
© 2015 Институт проблем криобиологии и криомедицины НАН Украины

Department of Low Temperature Preservation, Institute for Problems of Cryobiology and Cryomedicine of the National Academy of Sciences of Ukraine, Kharkov, Ukraine

***To whom correspondence should be addressed:**
23, Pereyaslavskaya str., Kharkov, Ukraine 61015;
tel.: +380 57 3733871, fax: +380 57 373 3084,
e-mail: todrin@mail.ru

Received September, 16, 2014
Accepted October, 02, 2014

Probl. Cryobiol. Cryomed. 2015. 25(1): 131–150.
© 2015 Institute for Problems of Cryobiology and Cryomedicine

поляризации и качестве диэлектрика. Поляризация диэлектрика определяется суммарным действием различных механизмов поляризации. По температурной и частотной зависимости диэлектрической проницаемости можно получить информацию о механизмах поляризации и их относительном вкладе в поляризацию диэлектрика. Возрастание диэлектрической проницаемости приводит к росту электропроводности.

Цель работы – обобщение и систематизация литературных данных на основе построения эмпирических формул для расчета значений статической диэлектрической проницаемости чистых криопротекторов, их водных растворов и смесей в зависимости от массовой концентрации криопротектора и температуры.

Экспериментальные результаты по статической диэлектрической проницаемости криопротекторов, водных растворов и смесей, приведенные в литературе, были обработаны с помощью программы «Excel 2003» («Microsoft», США). Наряду с данными для криопротекторов были обработаны и экспериментальные литературные данные для воды, льда и ряда растворов веществ, которые важны как для жизнедеятельности человека, так и для криобиологии.

В таблицах концентрации приведены в массовых процентах для вещества, указанного первым.

В таблицах приняты следующие условные обозначения:

БД – бутандиол,
БСА – бычий сывороточный альбумин,
ДМАц – диметилацетамид,
ДМСО – диметилсульфоксид,
ДМФА – диметилформамид,
ДЭГ – диэтиленгликоль,
М – молярность,
МАц – метилацетамид,
МФА – метилформамид,
ПВП – поливинилпирролидон,
ПД – пропандиол,
ПЭГ – полиэтиленгликоль,
ТЭГ – триэтиленгликоль,
ФА – формамид,
ХФ – хлороформ,
ЭГ – этиленгликоль,
ж. ф. – жидкая фаза,
тв. ф. – твердая фаза.

Temperature and frequency dependencies of dielectric permeability contain information about polarization mechanisms and their relative contribution into dielectric polarization. The increase in dielectric permeability results in rise of electric conductivity.

The research aim was to summarize and systematize the reported data, using the derived empirical formulae to calculate the values of static dielectric permeability for pure cryoprotectants, their aqueous solutions and mixtures depending on cryoprotectant mass concentration and temperature.

Collected published experimental data on static dielectric permeability for cryoprotectants, aqueous solutions and mixtures were processed with Excel 2003 software (Microsoft, USA). Along with the data for cryoprotectants we also processed the published experimental findings for water, ice and some solutions of substances, important for both human vital activity and cryobiology.

The Tables show concentrations in mass percentage for the substance mentioned first.

The following abbreviations are assumed in the Tables:

BD – butanediol,
BSA – bovine serum albumin,
CF – chloroform,
DMAc – dimethylacetamide,
DMSO – dimethyl sulfoxide,
DMFA – dimethylformamide,
DEG – diethylene glycol,
EG – ethylene glycol,
FA – formamide,
MAc – methylacetamide,
MFA – methylformamide,
PVP – polyvinylpyrrolidone,
PD – propanediol,
PEG – polyethylene glycol,
TEG – triethylene glycol,
l. p. – liquid phase,
s. p. – solid phase.



Таблица 1. Уравнения для расчета статической диэлектрической проницаемости чистых веществ в зависимости от температуры; дисперсии аппроксимаций и диапазоны температур применения уравнений
Table 1. Equations to calculate static dielectric permeability for pure substances depending on temperature; dispersions of approximations and temperature ranges of equation application

Вещество Substance	Уравнение Equation	R ²	Диапазон температур, °C Temperature range, °C	Источник	References
Вода, ж. ф. Water, l. p.	$\varepsilon = -9,712 \times 10^{-7}t^3 + 8,777 \times 10^{-4}t^2 - 0,4029t + 87,99$	0,9995	-40...370	[2, 10, 11, 15, 17, 23-25, 36, 37, 39, 40, 43, 54, 64, 66, 71, 78, 80, 96, 99, 103, 106]	[2, 3, 7, 9, 15-17, 28, 29, 31, 32, 35, 46, 58, 60, 61, 66, 75, 77, 93, 94, 97, 101, 104]
Вода, тв. ф. (лед) Water, s.p. (ice)	$\varepsilon = 2,8 \times 10^{-3}t^2 - 0,3076t + 93,8$	0,9945	-123...0	[14, 19, 36, 43, 54]	[4, 11, 28, 35, 46]
1,2-БД 1,2-BD	$\varepsilon = -0,1366t + 25,913$	0,9963	5...50	[2, 36]	[2, 28]
1,3-БД 1,3-BD	$\varepsilon = -1,317 \times 10^{-6}t^3 + 7,075 \times 10^{-4}t^2 - 0,1993t + 33,48$	0,9979	-28...150	[2, 4, 36]	[2, 28, 106]
1,4-БД 1,4-BD	$\varepsilon = 4,095 \times 10^{-4}t^2 - 0,1933t + 35,66$	0,9973	15...150	[2, 4, 9, 66]	[2, 61, 69, 106]
2,3-БД 2,3-BD	$\varepsilon = 2,351 \times 10^{-4}t^2 - 0,1144t + 23,69$	0,9992	10...150	[4, 103]	[101, 106]
1,2-ПД 1,2-PD	$\varepsilon = 2,159 \times 10^{-8}t^4 - 6,459 \times 10^{-6}t^3 + 9,836 \times 10^{-4}t^2 - 0,2017t + 34,0$	0,9965	-90...150	[2, 6, 16, 25, 26, 29, 34, 89, 92]	[2, 8, 17, 18, 21, 26, 53, 86, 89]
1,3-ПД 1,3-PD	$\varepsilon = 2,578 \times 10^{-6}t^3 + 2,844 \times 10^{-4}t^2 - 0,2024t + 39,18$	0,9978	-30...100	[36, 103]	[28, 101]
Ацетамид Acetamide	$\varepsilon = -2,249 \times 10^{-3}t^2 + 0,3312t + 55,97$	0,9994	91...175	[2, 36]	[2, 28]
Глицерин, ж. ф. Glycerol, l. p.	$\varepsilon = 5,134 \times 10^{-4}t^2 - 0,2663t + 48,61$	0,9933	-78...100	[2, 9, 25, 34, 35, 37, 61, 91, 93, 96, 103]	[2, 17, 26, 27, 29, 55, 69, 88, 90, 94, 101]
Глицерин, тв. ф. Glycerol, s. p.	$\varepsilon = 7,21 \times 10^{-4}t^3 + 0,1055t^2 + 5,207t + 91,58$	0,9997	-53...-13	[16]	[8]
	$\varepsilon = 1,183 \times 10^{-3}t^3 - 0,03185t^2 - 0,06638t + 47,12$	1,0	-13...17		
ДМАц DMAc	$\varepsilon = 6,584 \times 10^{-4}t^2 - 0,2495t + 44,3$	0,9912	-15...160	[2, 5, 36, 37, 53, 91, 103]	[2, 28, 29, 45, 47, 88, 101]
ДМСО DMSO	$\varepsilon = 2,966 \times 10^{-6}t^4 - 5,444 \times 10^{-4}t^3 + 3,527 \times 10^{-2}t^2 - 1,071t + 58,54$	0,993	10...70	[26, 35, 37, 93, 100, 103]	[18, 28, 29, 90, 98, 101]
ДМФА DMFA	$\varepsilon = -1,726 \times 10^{-6}t^3 + 8,004 \times 10^{-4}t^2 - 0,2114t + 42,12$	0,9953	-60...145	[2, 5, 9, 36, 103]	[2, 28, 47, 69, 101]
ДЭГ DEG	$\varepsilon = 1,09 \times 10^{-4}t^2 - 0,2042t + 36,04$	0,9942	-20...100	[2, 5, 36, 40, 70, 92]	[2, 28, 32, 47, 65, 89]
МАц MAc	$\varepsilon = -1,213 \times 10^{-5}t^3 + 7,393 \times 10^{-3}t^2 - 1,896t + 22,88$	0,9994	25...200	[2, 26, 36, 56]	[2, 18, 28, 49]
Метанол Methanol	$\varepsilon = -3,978 \times 10^{-6}t^3 + 1,045 \times 10^{-3}t^2 - 0,2309t + 37,39$	0,9946	-110...140	[2, 3, 5, 9, 23, 25, 27, 36, 38, 39, 49, 57, 66, 79, 80, 103]	[2, 15, 17, 19, 28, 30, 31, 41, 47, 50, 61, 69, 76, 77, 101, 105]
МФА MFA	$\varepsilon = 2,191 \times 10^{-6}t^3 + 7,628 \times 10^{-3}t^2 - 1,909t + 221,2$	0,991	-40...80	[2, 5, 36, 37, 103]	[2, 28, 29, 47, 101]
ПЭГ-1000 (тв. ф.) PEG-1000 (s. p.)	$\varepsilon = 6,429 \times 10^{-6}t^3 + 6,495 \times 10^{-4}t^2 + 0,04147t + 4,548$	0,9737	-70...30	[58]	[51]
ПЭГ-600 PEG-600	$\varepsilon = -6,3 \times 10^{-5}t^3 + 7,398 \times 10^{-3}t^2 - 0,2779t + 14,03$	0,9683	10...60	[58,86]	[51,83]

Продолжение на следующей странице
Continued on next page

Продолжение таблицы 1
Table 1. (Continued)

Вещество Substance	Уравнение Equation	R ²	Диапазон температур, °C Temperature range, °C	Источник	References
ПЭГ-400 PEG-400	$\varepsilon = 4,153 \times 10^{-4}t^2 - 0,1371t + 16,21$	0,9881	0...25	[86]	[83]
ПЭГ-300 PEG-300	$\varepsilon = 5,386 \times 10^{-4}t^2 - 0,132t + 17,5$	0,9817	0...25	[62, 86, 94]	[56, 83, 91]
ПЭГ-200 PEG-200	$\varepsilon = 5,524 \times 10^{-4}t^2 - 0,1639t + 23,79$	0,9749	4...25	[86, 94]	[83, 91]
ТЭГ TEG	$\varepsilon = 4,273 \times 10^{-4}t^2 - 0,1429t + 26,27$	0,9955	-20...60	[2, 5, 36]	[2, 28, 47]
Фенол Phenol	$\varepsilon = 2,656 \times 10^{-4}t^2 - 0,1034t + 15,38$	0,9954	4...160	[2, 36, 39]	[2, 28, 31]
Формаид Formamide	$\varepsilon = 7,988 \times 10^{-5}t^2 - 0,4343t + 119,4$	0,994	0...65	[2, 36, 103]	[2, 28, 101]
Хлороформ (тв. ф.) Chloroform (s. p.)	$\varepsilon = 5,78 \times 10^{-5}t^2 - 0,01432t + 3,318$	0,9689	-149...-70	[2, 79]	[2, 76]
Хлороформ Chloroform	$\varepsilon = 3,932 \times 10^{-5}t^2 - 0,01923t + 5,192$	0,9942	-70...180	[2, 25, 39, 66, 79]	[2, 17, 31, 61, 76]
Этанол Ethanol	$\varepsilon = 1,967 \times 10^{-8}t^4 - 4,341 \times 10^{-6}t^3 + 4,219 \times 10^{-4}t^2 - 0,1532t + 27,9$	0,9955	-143...160	[2, 5, 9, 24, 25, 36, 55, 57, 71, 79, 94, 103]	[2, 16, 17, 28, 47, 48, 50, 66, 69, 76, 91, 101]
ЭГ EG	$\varepsilon = 4,646 \times 10^{-4}t^2 - 0,2323t + 46,34$	0,9965	-20...150	[2, 25, 26, 36, 39, 40, 72, 80, 89, 93, 100]	[2, 17, 18, 28, 31, 32, 68, 77, 90, 98]

Таблица 2. Уравнения для расчета статической диэлектрической проницаемости растворов криопротекторов в зависимости от концентрации криопротекторов при фиксированной температуре; дисперсии аппроксимаций и диапазоны концентраций применения уравнений

Table 2. Equations to calculate static dielectric permeability for cryoprotective solutions depending on cryoprotectant concentration at a fixed temperature; dispersions of approximations and temperature ranges of equation application

Раствор Solution	Температура, °C Temperature, °C	Уравнение Equation	R ²	Диапазон концентраций, масс. % Concentration range, % w/w	Источник	References
1,2-ПД – вода 1,2-PD – water	25	$\varepsilon = -1,017 \times 10^{-3}C^2 - 0,3745C + 78,45$	0,9995	0...100	[26, 29, 103]	[18, 21, 101]
1,3-БД – вода 1,3-BD – water	25	$\varepsilon = -0,4971C + 78,45$	0,9999	0...100	[4, 6, 36, 76]	[28, 53, 73, 106]
CaCl ₂ -вода CaCl ₂ -water	25	$\varepsilon = -2,655 \times 10^{-3}C^3 + 0,168C^2 - 3,518C + 78,45$	0,9999	0...34	[1]	[1]
KCl-вода KCl-water	15	$\varepsilon = 0,7132C^2 - 3,6749C + 82,14$	0,99	0...2	[1]	[1]
	20	$\varepsilon = -1,6146C + 80,28$	0,9931	0...7	[47]	[39]
	25	$\varepsilon = -1,4552C + 78,45$	0,9901	0...14	[1, 51]	[1, 43]
	35	$\varepsilon = -1,7592C + 74,92$	0,9976	0...4	[1]	[1]
NaCl-вода NaCl-water	0	$\varepsilon = 6,723 \times 10^{-2}C^2 - 3,675C + 87,99$	0,9975	0...25	[1, 101]	[1, 99]
	1,5	$\varepsilon = 7,458 \times 10^{-2}C^2 - 3,398C + 87,39$	0,9939	0...25	[1, 51]	[1, 43]
	3	$\varepsilon = 6,957 \times 10^{-2}C^2 - 2,762C + 86,79$	0,991	0...5	[1]	[1]

Продолжение на следующей странице
Continued on next page



Продолжение таблицы 2
Table 2. (Continued)

Раствор Solution	Температура, °C Temperature, °C	Уравнение Equation	R ²	Диапазон концентраций, масс. % Concentration range, % w/w	Источник	References
NaCl-вода NaCl-water	5	$\varepsilon = 3,152 \times 10^{-2} C^2 - 2,689 C + 86,0$	0,9997	0...24	[48]	[40]
	10	$\varepsilon = 5,206 \times 10^{-2} C^2 - 3,399 C + 84,05$	0,9984	0...16	[1]	[1]
	20	$\varepsilon = 3,156 \times 10^{-2} C^2 - 2,33 C + 80,28$	0,9975	0...24	[48, 59]	[40, 52]
	25	$\varepsilon = 3,1 \times 10^{-2} C^2 - 2,273 C + 78,45$	0,9952	0...25	[1, 32, 33, 48, 101]	[1, 24, 25, 40, 99]
	30	$\varepsilon = 3,941 \times 10^{-2} C^2 - 2,584 C + 76,67$	0,9931	0...25	[1, 51, 101]	[1, 43, 99]
	35	$\varepsilon = 4,005 \times 10^{-2} C^2 - 2,222 C + 74,92$	0,9985	0...24	[48]	[40]
	40	$\varepsilon = 3,705 \times 10^{-2} C^2 - 2,862 C + 73,22$	0,9998	0...16	[1, 21]	[1, 13]
	50	$\varepsilon = 8,034 \times 10^{-2} C^2 - 3,057 C + 69,92$	0,9955	0...11	[101]	[99]
NaCl-глицерин NaCl-glycerol	-35,5	$\varepsilon = -1,249 \times 10^{-3} C^3 - 0,06069 C^2 - 1,181 C + 58,71$	0,9855	0...29	[1]	[1]
Аланин-вода Alanine-water	25	$\varepsilon = 0,1123 C^3 - 1,592 C^2 + 8,226 C + 78,45$	1,0	0...9	[28]	[20]
	30	$\varepsilon = 2,815 \times 10^{-2} C^3 - 0,3331 C^2 + 3,654 C + 76,67$	0,9974	0...9		
	35	$\varepsilon = 2,184 \times 10^{-2} C^3 - 0,3042 C^2 + 3,843 C + 74,92$	0,9949	0...9		
	40	$\varepsilon = 6,793 \times 10^{-2} C^3 - 1,018 C^2 + 5,871 C + 73,22$	0,9878	0...9		
BSA-вода BSA-water	25	$\varepsilon = -4,507 \times 10^{-2} C^4 + 0,432 C^3 - 1,5 C^2 + 1,362 C + 78,45$	0,9959	0...5	[12]	[4]
Галактоза-вода Galactose-water	5	$\varepsilon = -1,867 \times 10^{-3} C^2 - 0,1623 C + 86,0$	0,997	0...18	[1, 31]	[1, 23]
	10	$\varepsilon = -1,958 \times 10^{-3} C^2 - 0,1536 C + 84,05$	0,9949	0...18		
	15	$\varepsilon = -2,907 \times 10^{-3} C^2 - 0,1379 C + 82,14$	0,992	0...18		
	20	$\varepsilon = -3,91 \times 10^{-3} C^2 - 0,1277 C + 80,28$	0,9918	0...18		
	25	$\varepsilon = 5,812 \times 10^{-4} C^2 - 0,193 C + 78,45$	0,9944	0...60		
	30	$\varepsilon = 4,679 \times 10^{-4} C^2 - 0,2057 C + 76,67$	0,9966	0...60		
	35	$\varepsilon = -3,431 \times 10^{-3} C^2 - 0,1432 C + 74,92$	0,9972	0...18		
	40	$\varepsilon = 4,121 \times 10^{-4} C^2 - 0,1988 C + 73,22$	0,9964	0...60		
Глицерин-ДМАц Glycerol-DMAc	15	$\varepsilon = -7,24 \times 10^{-6} C^3 + 2,832 \times 10^{-4} C^2 + 0,08025 C + 40,71$	0,9958	0...100	[91]	[88]
	30	$\varepsilon = -2,808 \times 10^{-6} C^3 - 5,335 \times 10^{-4} C^2 + 0,1192 C + 37,41$	0,9978	0...100		
	45	$\varepsilon = 6,325 \times 10^{-7} C^3 - 1,146 \times 10^{-3} C^2 + 0,1542 C + 34,41$	0,9955	0...100		
	60	$\varepsilon = -2,325 \times 10^{-6} C^3 - 1,483 \times 10^{-3} C^2 + 0,1727 C + 31,7$	0,9969	0...100		
Глицерин-ДМФА Glycerol-DMFA	15	$\varepsilon = -1,102 \times 10^{-5} C^3 - 1,375 \times 10^{-4} C^2 + 0,1727 C + 39,12$	0,9913	0...100	[91]	[88]
	30	$\varepsilon = -2,359 \times 10^{-6} C^3 - 1,445 \times 10^{-3} C^2 + 0,2192 C + 36,45$	0,9939			

Продолжение на следующей странице
Continued on next page

Продолжение таблицы 2
Table 2. (Continued)

Раствор Solution	Температура, °C Temperature, °C	Уравнение Equation	R ²	Диапазон концентраций, масс. % Concentration range, % w/w	Источник	References	
Глицерин-DMФА Glycerol-DMFA	45	$\varepsilon = 1,673 \times 10^{-6} C^3 - 1,913 \times 10^{-3} C^2 + 0,2242 C + 34,07$	0,996	0...100	[91]	[88]	
	60	$\varepsilon = -8,459 \times 10^{-7} C^3 - 1,398 \times 10^{-3} C^2 + 0,1932 C + 31,94$	0,9947				
Глицерин-вода Glycerol-water	-19,5	$\varepsilon = -5,161 \times 10^{-3} C^2 + 0,1737 C + 87,75$	0,9987	85...100	[69]	[64]	
	-15,3	$\varepsilon = 1,042 \times 10^{-2} C^2 - 2,624 C + 210,9$	0,9953	85...100			
	-7,5	$\varepsilon = 2,971 \times 10^{-3} C^2 - 1,242 C + 145,5$	0,9976	85...100			
	20	$\varepsilon = -1,996 \times 10^{-3} C^2 - 0,1873 C + 80,28$	0,9966	0...100	[7, 35, 78]	[27, 59, 75]	
	25	$\varepsilon = -1,95 \times 10^{-3} C^2 - 0,1812 C + 78,45$	0,9944		[78, 84, 85, 96]	[75, 81, 82, 94]	
	30	$\varepsilon = -1,154 \times 10^{-3} C^2 - 0,2404 C + 76,67$	0,9989		[37, 41, 103]	[29, 33, 101]	
	35	$\varepsilon = -1,299 \times 10^{-3} C^2 - 0,2269 C + 74,92$	0,9994		[41, 85]	[33, 82]	
	37	$\varepsilon = -8,162 \times 10^{-4} C^2 - 0,2866 C + 74,24$	0,9991		[22]	[14]	
	40	$\varepsilon = -1,397 \times 10^{-3} C^2 - 0,2177 C + 73,22$	0,9992		[78, 96]	[75, 94]	
	45	$\varepsilon = -1,489 \times 10^{-3} C^2 - 0,2028 C + 71,55$	0,9976		[41, 85, 91]	[33, 82, 88]	
	60	$\varepsilon = -1,112 \times 10^{-3} C^2 - 0,2169 C + 66,77$	0,9996		[78]	[75]	
	70	$\varepsilon = -4,304 \times 10^{-4} C^2 - 0,2732 C + 63,75$	0,9985		[2, 22]	[2, 14]	
	80	$\varepsilon = -9,825 \times 10^{-4} C^2 - 0,2038 C + 60,88$	0,9994		[78]	[75]	
	100	$\varepsilon = -8,945 \times 10^{-4} C^2 - 0,1874 C + 55,51$	0,9998		[78]	[75]	
Глицерин-трегалоза Glycerol-trehalose	-23	$\varepsilon = 3,051 \times 10^{-6} C^5 - 3,06 \times 10^{-4} C^4 + 0,01126 C^3 - 0,1852 C^2 + 1,534 C + 6,8$	0,9953		0...47	[13]	[5]
	0	$\varepsilon = 1,963 \times 10^{-6} C^5 - 2,017 \times 10^{-4} C^4 + 7,807 \times 10^{-3} C^3 - 0,138 C^2 + 1,306 C + 7,426$	0,9953		0...47		
	24	$\varepsilon = 1,105 \times 10^{-6} C^5 - 1,254 \times 10^{-4} C^4 + 5,553 \times 10^{-3} C^3 - 0,1131 C^2 + 1,264 C + 7,51$	0,9942		0...47		
Глицерин-этанол Glycerol-ethanol	20	$\varepsilon = 5,628 \times 10^{-4} C^2 + 0,1126 C + 24,97$	0,9945	0...100	[7, 35]	[27, 59]	
	25	$\varepsilon = 1,202 \times 10^{-3} C^2 + 0,0615 C + 24,27$	0,9989		[88, 103]	[85, 101]	
Глицин – 2,84 % NaCl Glycine -- 2.84% NaCl	25	$\varepsilon = 3,2196 C + 77,293$	0,9996	0...20	[33]	[25]	
Глицин – 5,6 % NaCl Glycine – 5.6% NaCl	25	$\varepsilon = 3,1613 C + 76,767$	0,9999	0...20	[33]	[25]	
Глицин --10,85 % NaCl Glycine --10.85% NaCl	25	$\varepsilon = 3,2053 C + 74,893$	0,9996	0...20	[33]	[25]	
Глицин-вода Glycine-water	18	$\varepsilon = 3,1983 C + 81,02$	0,9994	0...18	[1]	[1]	
	20	$\varepsilon = 3,117 C + 80,28$	1,0	0...8			

Продолжение на следующей странице
Continued on next page



Продолжение таблицы 2
Table 2. (Continued)

Раствор Solution	Температура, °C Temperature, °C	Уравнение Equation	R ²	Диапазон концентраций, масс. % Concentration range, % w/w	Источник	References
Глицин-вода Glycine-water	25	$\varepsilon = 3,158C + 78,45$	0,9988	0...20	[1,33]	[1,25]
	30	$\varepsilon = 3,0653C + 76,67$	1,0	0...8	[1]	[1]
	40	$\varepsilon = 2,9908C + 73,22$	0,9999	0...8		
	50	$\varepsilon = 2,9553C + 69,92$	0,9999	0...8		
Глюкоза-вода Glucose-water	5	$\varepsilon = -6,815 \times 10^{-4}C^2 - 0,2608C + 86,0$	0,9988	0...18	[31]	[23]
	10	$\varepsilon = -8,703 \times 10^{-4}C^2 - 0,2493C + 84,05$	0,9994	0...18		
	15	$\varepsilon = -1,808 \times 10^{-3}C^2 - 0,2273C + 82,14$	0,9992	0...18		
	20	$\varepsilon = -1,159 \times 10^{-4}C^3 + 8,757 \times 10^{-3}C^2 - 0,3739C + 80,28$	0,995	0...90	[1, 31, 105]	[1, 23, 103]
	25	$\varepsilon = -1,688 \times 10^{-3}C^2 - 0,2165C + 78,45$	0,9999	0...50	[1, 31]	[1, 23]
	30	$\varepsilon = -3,884 \times 10^{-5}C^3 + 1,782 \times 10^{-3}C^2 - 0,2711C + 76,67$	0,9964	0...90	[1]	[1]
	35	$\varepsilon = -2,194 \times 10^{-3}C^2 - 0,2012C + 74,92$	0,9986	0...18	[31]	[23]
	40	$\varepsilon = -5,604 \times 10^{-5}C^3 + 3,217 \times 10^{-3}C^2 - 0,2155C + 73,22$	0,9941	0...90	[1]	[1]
	50	$\varepsilon = -4,582 \times 10^{-5}C^3 + 2,491 \times 10^{-3}C^2 - 0,1979C + 69,92$	0,9948	0...90		
	60	$\varepsilon = -3,842 \times 10^{-5}C^3 + 1,942 \times 10^{-3}C^2 - 0,1791C + 66,77$	0,9976	0...90		
	70	$\varepsilon = -4,394 \times 10^{-5}C^3 + 2,991 \times 10^{-3}C^2 - 0,2173C + 63,75$	0,9956	0...95		
	80	$\varepsilon = -4,363 \times 10^{-5}C^3 + 3,489 \times 10^{-3}C^2 - 0,2416C + 60,88$	0,9951	0...95		
90	$\varepsilon = -4,163 \times 10^{-5}C^3 + 3,818 \times 10^{-3}C^2 - 0,2656C + 58,13$	0,9935	0...95			
ДМАц-вода DMAc-water	25	$\varepsilon = -2,05 \times 10^{-3}C^2 - 0,2448C + 78,45$	0,9996	0...100	[5, 37, 103]	[29, 47, 101]
ДМСО-вода DMSO-water	10	$\varepsilon = -7,548 \times 10^{-5}C^3 + 6,396 \times 10^{-3}C^2 - 0,2148C + 84,05$	0,9982	0...100	[17, 100]	[9, 98]
	20	$\varepsilon = -5,583 \times 10^{-5}C^3 + 3,231 \times 10^{-3}C^2 - 0,09819C + 80,28$	0,9992		[17, 18, 35]	[9, 10, 27]
	25	$\varepsilon = -5,78 \times 10^{-5}C^3 + 3,824 \times 10^{-3}C^2 - 0,1025C + 78,45$	0,9972		[37, 45, 60, 74, 87, 97]	[29, 37, 54, 71, 84, 95]
	30	$\varepsilon = -5,101 \times 10^{-5}C^3 + 3,22 \times 10^{-3}C^2 - 0,1124C + 76,67$	0,9983		[17, 60, 103]	[9, 54, 101]
	35	$\varepsilon = -5,871 \times 10^{-5}C^3 + 4,961 \times 10^{-3}C^2 - 0,1977C + 74,92$	0,9975		[18, 60, 103]	[10, 54, 101]
	40	$\varepsilon = -4,769 \times 10^{-5}C^3 + 3,249 \times 10^{-3}C^2 - 0,1236C + 73,22$	0,9965		[17, 60, 103]	[9, 54, 101]
	45	$\varepsilon = -4,855 \times 10^{-5}C^3 + 3,754 \times 10^{-3}C^2 - 0,1484C + 71,55$	0,9982		[60, 103]	[54, 101]
ДМСО-ЭГ DMSO-EG	10	$\varepsilon = -5,816 \times 10^{-7}C^4 + 8,718 \times 10^{-5}C^3 - 5,598 \times 10^{-3}C^2 + 0,3368C + 44,06$	0,9945	0...100	[100, 103]	[98, 101]

Продолжение на следующей странице
Continued on next page

Продолжение таблицы 2
Table 2. (Continued)

Раствор Solution	Температура, °C Temperature, °C	Уравнение Equation	R ²	Диапазон концентраций, масс. % Concentration range, % w/w	Источник	References
ДМСО-ЭГ DMSO-EG	20	$\varepsilon = -8,862 \times 10^{-7} C^4 + 1,454 \times 10^{-4} C^3 - 9,183 \times 10^{-3} C^2 + 0,4166 C + 41,88$	0,9938	0...100	[100, 103]	[98, 101]
	25	$\varepsilon = -1,036 \times 10^{-6} C^4 + 1,861 \times 10^{-4} C^3 - 1,273 \times 10^{-2} C^2 + 0,5288 C + 40,82$	0,992	0...100		
	30	$\varepsilon = -1,389 \times 10^{-6} C^4 + 2,403 \times 10^{-4} C^3 - 1,487 \times 10^{-2} C^2 + 0,5435 C + 39,79$	0,9958	0...100		
	40	$\varepsilon = -1,29 \times 10^{-6} C^4 + 2,225 \times 10^{-4} C^3 - 1,422 \times 10^{-2} C^2 + 0,5673 C + 37,79$	0,9972	0...100		
ДМФА-вода DMFA-water	25	$\varepsilon = 1,605 \times 10^{-6} C^3 - 3,092 \times 10^{-3} C^2 - 0,1193 C + 78,45$	0,9992	0...100	[1, 37, 103]	[1, 29, 101]
	30	$\varepsilon = 1,803 \times 10^{-6} C^3 - 2,525 \times 10^{-3} C^2 - 0,1645 C + 76,67$	0,999	0...100	[93, 103]	[90, 101]
ДМФА-глицерин DMFA-glycerol	30	$\varepsilon = 6,273 \times 10^{-6} C^3 - 2,606 \times 10^{-3} C^2 + 0,1548 C + 41,08$	0,998	0...100	[93,103]	[90,101]
ДМФА-ДМСО DMFA-DMSO	30	$\varepsilon = -4,021 \times 10^{-4} C^2 - 0,05143 C + 45,86$	0,9971	0...100	[93,103]	[90,101]
ДМФА-метанол DMFA-methanol	10	$\varepsilon = -1,065 \times 10^{-3} C^2 + 0,1592 C + 35,18$	0,996	0...100	[1]	[1]
	25	$\varepsilon = 3,002 \times 10^{-4} C^2 + 0,03135 C + 32,21$	0,994		[2, 49, 103]	[2, 41, 101]
	30	$\varepsilon = 3,066 \times 10^{-4} C^2 + 0,03049 C + 31,3$	0,9933			
	35	$\varepsilon = 3,943 \times 10^{-4} C^2 + 0,01649 C + 30,42$	0,9976			
	40	$\varepsilon = 5,479 \times 10^{-4} C^2 - 3,879 \times 10^{-3} C + 29,57$	0,9953			
	55	$\varepsilon = -1,024 \times 10^{-3} C^2 + 0,1583 C + 27,19$	0,9962		[1]	[1]
ДМФА-ЭГ DMFA-EG	30	$\varepsilon = 2,032 \times 10^{-6} C^3 - 1,469 \times 10^{-3} C^2 + 0,09594 C + 39,79$	0,9987	0...100	[93, 103]	[90, 101]
ДМФА-этанол DMFA-ethanol	30	$\varepsilon = 2,327 \times 10^{-4} C^2 + 0,1064 C + 23,58$	0,9987	0...100	[93, 103]	[90, 101]
ДЭГ-вода DEG-water	15	$\varepsilon = -2,113 \times 10^{-3} C^2 - 0,2804 C + 82,14$	0,9996	0...100	[1, 36]	[1, 28]
	25	$\varepsilon = -1,997 \times 10^{-3} C^2 - 0,275 C + 78,45$	0,9991	0...100	[1, 40, 94]	[1, 32, 91]
	35	$\varepsilon = -1,765 \times 10^{-3} C^2 - 0,2778 C + 74,92$	0,9997	0...100	[1, 2]	[1, 2]
ДЭГ-этанол DEG-ethanol	25	$\varepsilon = 4,69 \times 10^{-5} C^2 + 0,06224 C + 24,27$	0,9965	0...100	[94,103]	[91,101]
Ксилроза-вода Xylose-water	5	$\varepsilon = -0,307 C + 86,0$	0,9984	0...16	[31]	[23]
	10	$\varepsilon = -0,3028 C + 84,05$	0,9992			
	15	$\varepsilon = -0,3006 C + 82,14$	0,9991			
	20	$\varepsilon = -0,3056 C + 80,28$	0,9957			
	25	$\varepsilon = -0,3 C + 78,45$	0,9959			
	30	$\varepsilon = -0,3068 C + 76,67$	0,9941			
	35	$\varepsilon = -0,3123 C + 74,92$	0,9918			
	40	$\varepsilon = -0,3206 C + 73,22$	0,9894			
Мальтоза-вода Maltose-water	5	$\varepsilon = -2,126 \times 10^{-3} C^2 - 0,2596 C + 86,0$	0,9987	0...50	[68]	[63]

Продолжение на следующей странице
Continued on next page



Продолжение таблицы 2
Table 2. (Continued)

Раствор Solution	Температура, °C Temperature, °C	Уравнение Equation	R ²	Диапазон концентраций, масс. % Concentration range, % w/w	Источник	References
Мальтоза-вода Maltose-water	15	$\varepsilon = -1,622 \times 10^{-3} C^2 - 0,2652 C + 82,14$	0,9982	0...50	[68]	[63]
	25	$\varepsilon = -1,427 \times 10^{-3} C^2 - 0,2625 C + 78,45$	0,9993			
	35	$\varepsilon = -1,124 \times 10^{-3} C^2 - 0,2656 C + 74,92$	0,9991			
Маннит-вода Mannitol-water	20	$\varepsilon = -1,632 \times 10^{-3} C^2 - 0,1237 C + 80,28$	0,9988	0...15	[1]	[1]
	25	$\varepsilon = -8,461 \times 10^{-3} C^2 - 6,887 \times 10^{-3} C + 78,45$	0,9982	0...50	[1, 92]	[1, 89]
	30	$\varepsilon = -9,355 \times 10^{-4} C^2 - 0,1331 C + 76,67$	0,9982	0...20	[1]	[1]
	40	$\varepsilon = 6,645 \times 10^{-4} C^2 - 0,1687 C + 73,22$	0,9997	0...20		
	50	$\varepsilon = -2,258 \times 10^{-4} C^2 - 0,1543 C + 69,92$	0,9998	0...20		
	60	$\varepsilon = 1,194 \times 10^{-3} C^2 - 0,1806 C + 66,77$	0,9991	0...20		
МАц-вода MAc-water	5	$\varepsilon = 1,38 \times 10^{-4} C^3 - 9,82 \times 10^{-3} C^2 + 0,393 C + 86,0$	0,9993	0...80	[26]	[18]
	10	$\varepsilon = 1,556 \times 10^{-4} C^3 - 1,278 \times 10^{-2} C^2 + 0,4797 C + 84,5$	0,9991	0...80		
	15	$\varepsilon = 1,673 \times 10^{-4} C^3 - 1,523 \times 10^{-2} C^2 + 0,5828 C + 82,14$	0,9996	0...80		
	20	$\varepsilon = 1,844 \times 10^{-4} C^3 - 1,791 \times 10^{-2} C^2 + 0,6667 C + 80,28$	0,9996	0...80		
	25	$\varepsilon = -4,259 \times 10^{-6} C^4 + 8,945 \times 10^{-4} C^3 - 5,616 \times 10^{-2} C^2 + 1,342 C + 78,45$	0,9956	0...100		
	30	$\varepsilon = -2,852 \times 10^{-6} C^4 + 6,423 \times 10^{-4} C^3 - 4,233 \times 10^{-2} C^2 + 1,111 C + 76,67$	0,9985	0...100		
	35	$\varepsilon = -3,002 \times 10^{-6} C^4 + 7,283 \times 10^{-4} C^3 - 5,184 \times 10^{-2} C^2 + 1,386 C + 74,92$	0,9999	0...100		
	40	$\varepsilon = -2,916 \times 10^{-6} C^4 + 7,722 \times 10^{-4} C^3 - 5,961 \times 10^{-2} C^2 + 1,671 C + 73,22$	0,9995	0...100		
	45	$\varepsilon = -3,011 \times 10^{-6} C^4 + 8,446 \times 10^{-4} C^3 - 6,806 \times 10^{-2} C^2 + 1,92 C + 71,55$	0,9968	0...100		
Метанол-вода Methanol-water	-90	$\varepsilon = 8,921 \times 10^{-3} C^2 - 2,163 C + 193,9$	0,9858	54...100	[1]	[1]
	-80	$\varepsilon = 7,836 \times 10^{-3} C^2 - 1,959 C + 179,8$	0,987			
	-70	$\varepsilon = 6,708 \times 10^{-3} C^2 - 1,757 C + 166,9$	0,9893			
	-60	$\varepsilon = 2,865 \times 10^{-3} C^2 - 1,11 C + 136,6$	0,9919	44...100	[1, 3]	[1, 105]
	-50	$\varepsilon = 2,881 \times 10^{-3} C^2 - 1,08 C + 130,5$	0,9918	0...100		
	-40	$\varepsilon = -1,177 \times 10^{-3} C^2 - 0,4614 C + 105,57$	0,9968			
	-30	$\varepsilon = -9,911 \times 10^{-4} C^2 - 0,4614 C + 100,89$	0,998			
	-20	$\varepsilon = -7,725 \times 10^{-4} C^2 - 0,4668 C + 96,41$	0,9926			
	-10	$\varepsilon = -6,287 \times 10^{-4} C^2 - 0,4477 C + 92,11$	0,9945			
	0	$\varepsilon = -4,905 \times 10^{-4} C^2 - 0,4513 C + 87,99$	0,9996			
	5	$\varepsilon = -6,698 \times 10^{-4} C^2 - 0,4239 C + 86,0$	0,9998			
	10	$\varepsilon = -3,032 \times 10^{-4} C^2 - 0,455 C + 84,05$	0,9992			
				[1]	[1]	

Продолжение на следующей странице
Continued on next page

Продолжение таблицы 2
Table 2. (Continued)

Раствор Solution	Температура, °C Temperature, °C	Уравнение Equation	R ²	Диапазон концентраций, масс. % Concentration range, % w/w	Источник	References
Метанол-вода Methanol-water	15	$\varepsilon = -4,734 \times 10^{-4} C^2 - 0,4255C + 82,14$	0,9999	0...100	[1, 23, 42, 103]	[1, 15, 34, 101]
	17	$\varepsilon = -1,87 \times 10^{-4} C^2 - 0,4639C + 81,39$	0,9997		[1]	[1]
	20	$\varepsilon = -2,023 \times 10^{-4} C^2 - 0,4481C + 80,28$	0,9974		[1, 42, 71, 103]	[1, 34, 66, 101]
	25	$\varepsilon = -1,501 \times 10^{-4} C^2 - 0,4414C + 78,45$	0,999		[1, 23, 41, 42, 52, 87, 102, 103]	[1, 15, 33, 34, 44, 84, 100, 101]
	30	$\varepsilon = -2,118 \times 10^{-4} C^2 - 0,4267C + 76,67$	0,9983		[1, 41, 42, 98, 103]	[1, 33, 34, 96, 101]
	35	$\varepsilon = -2,631 \times 10^{-4} C^2 - 0,4137C + 74,92$	0,9985		[1, 23, 41, 42, 103]	[1, 15, 33, 34, 101]
	40	$\varepsilon = -8,251 \times 10^{-5} C^2 - 0,4253C + 73,22$	0,9993		[1, 41, 103]	[1, 33, 101]
	45	$\varepsilon = -1,092 \times 10^{-4} C^2 - 0,4157C + 71,55$	0,9995		[23, 41, 103]	[15, 33, 101]
	50	$\varepsilon = -1,017 \times 10^{-3} C^2 - 0,3775C + 69,92$	0,9973		[1, 30, 103]	[1, 22, 101]
	55	$\varepsilon = 9,783 \times 10^{-5} C^2 - 0,4193C + 68,32$	1,0		[23, 103]	[15, 101]
	60	$\varepsilon = 4,72 \times 10^{-4} C^2 - 0,4525C + 66,77$	0,9994		[1, 2, 103]	[1, 2, 101]
Метанол-ДМСО Methanol-DMSO	20	$\varepsilon = 2,01 \times 10^{-5} C^3 - 3,858 \times 10^{-3} C^2 + 0,04268C + 47,35$	0,9992	0...100	[8]	[67]
Мочевина-вода Urea-water	18	$\varepsilon = -3,588 \times 10^{-2} C^2 + 0,2269C + 81,01$	0,9969	1,6...9,5	[1]	[1]
	20	$\varepsilon = 1,872 \times 10^{-3} C^2 + 0,5109C + 80,28$	0,9996	0...48	[1, 67]	[1, 62]
	25	$\varepsilon = 1,153 \times 10^{-3} C^2 + 0,5321C + 78,45$	1,0	0...28	[1, 46]	[1, 38]
МФА-вода MFA-water	25	$\varepsilon = 2,498 \times 10^{-6} C^4 - 3,086 \times 10^{-4} C^3 + 1,404 \times 10^{-2} C^2 + 0,1484C + 78,45$	0,9996	0...100	[37]	[29]
ПЭГ-200 – вода PEG-200 – water	25	$\varepsilon = -2,627 \times 10^{-3} C^2 - 0,316C + 78,45$	0,9989	0...100	[53,92,94]	[45,89,91]
ПЭГ-300 – вода PEG-300 – water	25	$\varepsilon = -2,792 \times 10^{-3} C^2 - 0,3287C + 78,45$	0,9962	0...100	[53,62,94]	[45,56,91]
ПЭГ-400 – вода PEG-400 – water	25	$\varepsilon = -2,784 \times 10^{-3} C^2 - 0,3641C + 78,45$	0,9969	0...100	[62,94]	[56,91]
ПЭГ-600 – вода PEG-600 – water	25	$\varepsilon = -1,933 \times 10^{-3} C^2 - 0,4586C + 78,45$	0,9981	0...100	[53,62,94]	[45,56,91]
ПЭГ-200 – этанол PEG-200 – ethanol	25	$\varepsilon = -2,617 \times 10^{-4} C^2 - 0,01805C + 24,27$	0,9939	0...100	[94]	[91]
ПЭГ-300 – этанол PEG-300 – ethanol	25	$\varepsilon = -3,042 \times 10^{-4} C^2 - 0,04003C + 24,27$	0,9962	0...100	[94]	[91]
ПЭГ-400 – этанол PEG-400 – ethanol	25	$\varepsilon = -3,525 \times 10^{-4} C^2 - 0,0576C + 24,27$	0,9908	0...100	[88]	[85]
ПЭГ-600 – этанол PEG-600 – ethanol	25	$\varepsilon = -4,406 \times 10^{-4} C^2 - 0,06083C + 24,27$	0,9966	0...100	[94]	[91]
Рибоза-вода Ribose-water	5	$\varepsilon = -6,204 \times 10^{-3} C^2 - 0,1941C + 86,0$	0,9969	0...16	[31]	[23]
	10	$\varepsilon = -7,789 \times 10^{-3} C^2 - 0,1854C + 84,05$	0,9967			
	15	$\varepsilon = -1,017 \times 10^{-2} C^2 - 0,1832C + 82,14$	0,9962			

Продолжение на следующей странице
Continued on next page



Продолжение таблицы 2
Table 2. (Continued)

Раствор Solution	Температура, °C Temperature, °C	Уравнение Equation	R ²	Диапазон концентраций, масс. % Concentration range, % w/w	Источник	References
Рибоза-вода Ribose-water	20	$\varepsilon = -1,159 \times 10^{-2} C^2 - 0,2004 C + 80,28$	0,9966	0...16	[31]	[23]
	25	$\varepsilon = -1,225 \times 10^{-2} C^2 - 0,2285 C + 78,45$	0,9944			
	30	$\varepsilon = -1,31 \times 10^{-2} C^2 - 0,2884 C + 76,67$	0,9954			
	35	$\varepsilon = -1,069 \times 10^{-2} C^2 - 0,4227 C + 74,92$	0,9968			
	40	$\varepsilon = -5,65 \times 10^{-3} C^2 - 0,6354 C + 73,22$	0,9896			
Сахароза-вода Sucrose-water	10	$\varepsilon = -9,134 \times 10^{-4} C^2 - 0,2447 C + 84,05$	1,0	0...40	[1]	[1]
	20	$\varepsilon = -7,683 \times 10^{-5} C^3 + 4,314 \times 10^{-3} C^2 - 0,3083 C + 80,28$	0,9976	0...80	[1, 12, 63]	[1, 4, 57]
	22	$\varepsilon = -1,239 \times 10^{-2} C^2 - 0,129 C + 79,54$	0,9969	0...14	[73]	[70]
	25	$\varepsilon = -1,466 \times 10^{-3} C^2 - 0,214 C + 78,45$	0,9974	0...60	[1, 12, 63]	[1, 4, 57]
	30	$\varepsilon = -2,311 \times 10^{-3} C^2 - 0,1758 C + 76,67$	0,9967	0...70		
	35	$\varepsilon = -2,592 \times 10^{-3} C^2 - 0,2083 C + 74,92$	0,9916	0...25	[11]	[3]
	40	$\varepsilon = -2,656 \times 10^{-3} C^2 - 0,1504 C + 73,22$	0,9948	0...80	[1]	[1]
	45	$\varepsilon = -4,704 \times 10^{-3} C^2 - 0,1498 C + 71,55$	0,9969	0...25	[11]	[3]
	50	$\varepsilon = -2,027 \times 10^{-3} C^2 - 0,1724 C + 69,92$	0,997	0...80	[1]	[1]
	60	$\varepsilon = -3,374 \times 10^{-5} C^3 + 1,684 \times 10^{-3} C^2 - 0,2531 C + 66,77$	0,995	0...90		
	70	$\varepsilon = -1,816 \times 10^{-5} C^3 + 5,138 \times 10^{-4} C^2 - 0,2392 C + 63,75$	0,9959	0...90		
	80	$\varepsilon = -1,908 \times 10^{-5} C^3 + 1,361 \times 10^{-3} C^2 - 0,2815 C + 60,88$	0,9953	0...90		
	90	$\varepsilon = -3,256 \times 10^{-5} C^3 + 3,096 \times 10^{-3} C^2 - 0,3102 C + 58,13$	0,9956	0...90		
	95	$\varepsilon = -1,699 \times 10^{-3} C^2 - 0,1324 C + 56,8$	0,9997	0...90		
	100	$\varepsilon = -4,09 \times 10^{-4} C^2 - 0,2539 C + 55,51$	0,9997	0...70		
Сорбит-вода Sorbitol-water	0	$\varepsilon = 1,231 \times 10^{-3} C^2 - 0,4114 C + 87,99$	0,9871	0...70	[95]	[92]
	5	$\varepsilon = 1,7 \times 10^{-3} C^2 - 0,4467 C + 86,0$	0,9877	0...70		
	10	$\varepsilon = 4,435 \times 10^{-3} C^2 - 0,6147 C + 84,05$	0,9942	0...70		
	15	$\varepsilon = -3,269 \times 10^{-4} C^3 + 3,702 \times 10^{-2} C^2 - 1,394 C + 82,14$	0,9987	0...60		
	20	$\varepsilon = -3,102 \times 10^{-4} C^3 + 3,375 \times 10^{-2} C^2 - 1,253 C + 80,28$	0,9961	0...60		
	25	$\varepsilon = -4,007 \times 10^{-4} C^3 + 4,092 \times 10^{-2} C^2 - 1,394 C + 78,45$	0,9954	0...50		
Трегалоза-вода Trehalose-water	5	$\varepsilon = -1,811 \times 10^{-3} C^2 - 0,2206 C + 86,0$	0,9989	0...50	[68]	[63]
	15	$\varepsilon = -1,377 \times 10^{-3} C^2 - 0,2141 C + 82,14$	0,9993	0...50		
	25	$\varepsilon = -9,856 \times 10^{-4} C^2 - 0,2252 C + 78,45$	0,9961	0...50		
	35	$\varepsilon = -7,602 \times 10^{-4} C^2 - 0,2316 C + 74,92$	0,9957	0...50		

Продолжение на следующей странице
Continued on next page

Продолжение таблицы 2
Table 2. (Continued)

Раствор Solution	Температура, °C Temperature, °C	Уравнение Equation	R ²	Диапазон концентраций, масс. % Concentration range, % w/w	Источник	References
ТЭГ-вода TEG-water	15	$\varepsilon = -2,481 \times 10^{-3} C^2 - 0,3227 C + 82,14$	0,999	0...100	[1]	[1]
	25	$\varepsilon = -2,539 \times 10^{-3} C^2 - 0,2927 C + 78,45$	0,9995	0...100	[1, 40]	[1, 32]
	35	$\varepsilon = -2,323 \times 10^{-3} C^2 - 0,2925 C + 74,92$	0,9992	0...100		
Фенол-вода Phenol-water	70	$\varepsilon = -1,543 \times 10^{-3} C^2 - 0,09431 C + 33,87$	0,9991	40...100	[1, 2]	[1, 2]
ФА – 1,2-ПД FA – 1,2-PD	30	$\varepsilon = 0,7806 C + 28,68$	0,9997	0...100	[92]	[89]
ФА-вода FA-water	25	$\varepsilon = -4,097 \times 10^{-5} C^3 + 3,555 \times 10^{-3} C^2 + 0,3663 C + 78,45$	0,9966	0...100	[1,37,52]	[1,29,44]
	30	$\varepsilon = -5,644 \times 10^{-5} C^3 + 5,358 \times 10^{-3} C^2 + 0,3315 C + 76,67$	0,9987	0...100		
ФА-глицерин FA-glycerol	30	$\varepsilon = -2,528 \times 10^{-3} C^2 + 0,9119 C + 41,08$	0,9993	0...100		
ФА-ДЭГ FA-DEG	30	$\varepsilon = -1,997 \times 10^{-3} C^2 + 0,8699 C + 39,99$	0,9994	0...100	[92]	[89]
ФА-ДМСО FA-DMSO	30	$\varepsilon = 1,127 \times 10^{-3} C^2 + 0,4993 C + 45,86$	0,9996	0...100		
ФА-ДМФА FA-DMFA	30	$\varepsilon = 1,87 \times 10^{-3} C^2 + 0,5171 C + 36,45$	0,9997	0...100	[90,92]	[87,89]
ФА-метанол FA-methanol	30	$\varepsilon = 1,905 \times 10^{-3} C^2 + 0,5719 C + 31,3$	0,9995	0...100		
ФА – ПЭГ-200 FA – PEG-200	30	$\varepsilon = 0,8717 C + 19,37$	0,9995	0...100		
ФА – ПЭГ-300 FA – PEG-300	30	$\varepsilon = 0,9187 C + 14,02$	0,999	0...100		
ФА – ПЭГ-400 FA – PEG-400	30	$\varepsilon = 8,159 \times 10^{-4} C^2 + 0,8548 C + 12,47$	0,9991	0...100	[92]	[89]
ФА – ПЭГ-600 FA – PEG-600	30	$\varepsilon = 7,358 \times 10^{-4} C^2 + 0,8803 C + 10,65$	0,9993	0...100		
ФА-этанол FA-ethanol	30	$\varepsilon = 4,864 \times 10^{-3} C^2 + 0,3494 C + 23,58$	0,9998	0...100		
ФА-ЭГ FA-EG	30	$\varepsilon = -1,728 \times 10^{-3} C^2 + 0,8454 C + 39,79$	0,9997	0...100		
Фруктоза-вода Fructose-water	5	$\varepsilon = -1,047 \times 10^{-3} C^2 - 0,2451 C + 86,0$	0,9997	0...18		
	10	$\varepsilon = -1,282 \times 10^{-3} C^2 - 0,2268 C + 84,05$	0,9998	0...18		
	15	$\varepsilon = -1,495 \times 10^{-3} C^2 - 0,2176 C + 82,14$	0,9996	0...18		
	20	$\varepsilon = -1,005 \times 10^{-3} C^2 - 0,2192 C + 80,28$	0,9988	0...18	[31]	[23]
	25	$\varepsilon = -1,249 \times 10^{-3} C^2 - 0,2069 C + 78,45$	0,9992	0...18		
	30	$\varepsilon = -1,565 \times 10^{-3} C^2 - 0,1996 C + 76,67$	0,9997	0...18		
	35	$\varepsilon = -1,655 \times 10^{-3} C^2 - 0,188 C + 74,92$	0,9991	0...18		
	40	$\varepsilon = -1,762 \times 10^{-3} C^2 - 0,1847 C + 73,22$	0,9951	0...20	[12, 31]	[4, 23]
ХФ-метанол CF-methanol	20	$\varepsilon = -1,916 \times 10^{-3} C^2 - 0,09204 C + 33,16$	0,9996	0...100	[1]	[1]

Продолжение на следующей странице
Continued on next page



Продолжение таблицы 2
Table 2. (Continued)

Раствор Solution	Температура, °C Temperature, °C	Уравнение Equation	R ²	Диапазон концентраций, масс. % Concentration range, % w/w	Источник	References
ХФ-этанол CF-ethanol	18	$\varepsilon = -1,096 \times 10^{-3} C^2 - 0,09585 C + 25,26$	0,9975	0...100	[1]	[1]
	25	$\varepsilon = -1,079 \times 10^{-3} C^2 - 0,08791 C + 24,27$	0,998			
Этанол-вода Ethanol-water	-5	$\varepsilon = 1,703 \times 10^{-4} C^2 - 0,6328 C + 90,03$	0,9975		[1, 11, 103]	[1, 3, 101]
	0	$\varepsilon = 2,313 \times 10^{-4} C^2 - 0,6284 C + 87,99$	0,9981		[24]	[16]
	5	$\varepsilon = -3,514 \times 10^{-4} C^2 - 0,6131 C + 86,0$	0,9988		[1, 11, 103]	[1, 3, 101]
	10	$\varepsilon = 7,248 \times 10^{-4} C^2 - 0,6494 C + 84,05$	0,9942		[11, 24, 103]	[3, 16, 101]
	15	$\varepsilon = 2,165 \times 10^{-4} C^2 - 0,6073 C + 82,14$	0,9953		[1, 7, 42, 55, 71, 103]	[1, 34, 48, 59, 66, 101]
	20	$\varepsilon = 6,742 \times 10^{-4} C^2 - 0,623 C + 80,28$	0,9965		[73]	[70]
	22	$\varepsilon = 4,974 \times 10^{-4} C^2 - 0,6052 C + 79,56$	0,9999		[1, 11, 24, 42, 44, 52, 87, 88, 104, 103]	[1, 3, 16, 34, 36, 44, 84, 85, 101, 102]
	25	$\varepsilon = 7,513 \times 10^{-4} C^2 - 0,6207 C + 78,45$	0,9982		[1, 98, 103]	[1, 96, 101]
	30	$\varepsilon = 7,52 \times 10^{-4} C^2 - 0,6106 C + 76,67$	0,999		[55, 103]	[48, 101]
	32	$\varepsilon = 5,385 \times 10^{-4} C^2 - 0,5772 C + 75,96$	0,9998		[1, 11, 24, 103]	[1, 3, 16, 101]
	35	$\varepsilon = 7,22 \times 10^{-4} C^2 - 0,6015 C + 74,92$	0,997		[1, 11, 42, 103]	[1, 3, 34, 101]
	40	$\varepsilon = 8,497 \times 10^{-4} C^2 - 0,6016 C + 73,22$	0,9983		[1, 11, 103]	[1, 3, 101]
	45	$\varepsilon = 9,567 \times 10^{-4} C^2 - 0,6092 C + 71,55$	0,9927		[1, 24, 30, 103]	[1, 16, 22, 101]
	50	$\varepsilon = 9,68 \times 10^{-4} C^2 - 0,5955 C + 69,92$	0,9982		[1, 103]	[1, 101]
	55	$\varepsilon = 1,053 \times 10^{-3} C^2 - 0,5913 C + 68,32$	0,9992		[1, 101, 103]	[1, 99, 101]
	60	$\varepsilon = 9,703 \times 10^{-4} C^2 - 0,5725 C + 66,77$	0,9991		[1, 40]	[1, 32]
	75	$\varepsilon = 1,02 \times 10^{-3} C^2 - 0,5519 C + 62,3$	0,9993		[70, 77, 101, 106]	[65, 74, 99, 104]
80	$\varepsilon = 8,857 \times 10^{-4} C^2 - 0,536 C + 60,88$	0,9995	[1, 20, 40, 72, 80, 94, 106]		[1, 12, 32, 68, 77, 91, 104]	
ЭГ-вода EG-water	15	$\varepsilon = -1,975 \times 10^{-3} C^2 - 0,1885 C + 82,14$	0,9973	[80]	[77]	
	20	$\varepsilon = -1,894 \times 10^{-3} C^2 - 0,2224 C + 80,28$	0,9955	[1, 40, 80]	[1, 32, 77]	
	25	$\varepsilon = -1,819 \times 10^{-3} C^2 - 0,205 C + 78,45$	0,9935	[70, 77, 80, 106]	[65, 74, 77, 104]	
	30	$\varepsilon = -1,707 \times 10^{-3} C^2 - 0,2216 C + 76,67$	0,9975	[80]	[77]	
	35	$\varepsilon = -1,442 \times 10^{-3} C^2 - 0,2174 C + 74,92$	0,9946	[1, 40, 80]	[1, 32, 77]	
	40	$\varepsilon = -1,622 \times 10^{-3} C^2 - 0,2219 C + 73,22$	0,9971	[70, 77, 80, 106]	[65, 74, 77, 104]	
	45	$\varepsilon = -1,406 \times 10^{-3} C^2 - 0,2307 C + 71,55$	0,9999	[80]	[77]	
	50	$\varepsilon = -7,672 \times 10^{-4} C^2 - 0,2722 C + 69,92$	0,9962	[30]	[22]	
	60	$\varepsilon = -1,112 \times 10^{-3} C^2 - 0,2387 C + 66,77$	0,9988	[70, 77, 101, 106]	[65, 74, 99, 104]	
	80	$\varepsilon = -7,978 \times 10^{-4} C^2 - 0,2419 C + 60,88$	0,9995	[70, 77, 106]	[65, 74, 104]	
ЭГ-этанол EG-ethanol	100	$\varepsilon = -5,427 \times 10^{-4} C^2 - 0,2435 C + 55,51$	0,9995	[70, 77, 101, 106]	[65, 74, 99, 104]	
	25	$\varepsilon = 7,618 \times 10^{-4} C^2 + 0,09216 C + 24,27$	0,9979	[94]	[91]	



Таблица 3. Уравнения для расчета статической диэлектрической проницаемости растворов криопротекторов в зависимости от температуры при фиксированной концентрации; дисперсии аппроксимаций и диапазоны концентраций применения уравнений

Table 3. Equations to calculate static dielectric permeability for cryoprotective solutions depending on temperature at a fixed concentration; dispersions of approximations and temperature ranges of equation application

Раствор Solution	Концентрация, масс. % Concentration, % w/w	Уравнение Equation	R ²	Диапазон температур, °C Temperature range, °C	Источник	References
NaCl-вода NaCl-water	0,5	$\varepsilon = -4,19 \times 10^{-3}t^2 - 0,03055t + 79,98$	0,9966	10...60	[83]	[80]
	1	$\varepsilon = -5,05 \times 10^{-3}t^2 - 0,03674t + 77,36$	0,9975	10...60		
	1,5	$\varepsilon = -4,785 \times 10^{-3}t^2 - 7,846 \times 10^{-3}t + 76,66$	0,994	10...60		
	2	$\varepsilon = -1,372 \times 10^{-3}t^2 - 0,1563t + 76,78$	0,9982	10...50	[1]	[1]
	2,84	$\varepsilon = -5,143 \times 10^{-4}t^2 - 0,3114t + 79,57$	0,9966	0...60	[51]	[43]
	3,73	$\varepsilon = -1,357 \times 10^{-3}t^2 - 0,3567t + 79,19$	0,9956	0...40		
NaCl – агар-гель (1%) NaCl – agar gel (1%)	0	$\varepsilon = 3,709 \times 10^{-4}t^2 - 0,2419t + 79,54$	0,9973	10...60	[83]	[80]
	0,5	$\varepsilon = -1,481 \times 10^{-3}t^2 - 0,1366t + 77,43$	0,9956	10...60		
	1	$\varepsilon = 6,893 \times 10^{-4}t^2 - 0,2563t + 76,45$	0,9973	10...60		
	1,5	$\varepsilon = 7,719 \times 10^{-4}t^2 - 0,249t + 75,44$	0,9913	10...60		
	2	$\varepsilon = 1,384 \times 10^{-3}t^2 - 0,2738t + 73,98$	0,9993	10...60		
NaCl-глицерин NaCl-glycerol	4,55	$\varepsilon = 1,029 \times 10^{-2}t^2 + 0,501t + 58,5$	1,0	-49...-27	[1]	[1]
	21,15	$\varepsilon = 6,363 \times 10^{-3}t^2 - 0,2968t + 49,39$	0,9968	-50...-22		
NaCl – глициновый буфер (0,2 M) NaCl – glycine buffer (0.2 M)	0	$\varepsilon = 1,818 \times 10^{-5}t^4 - 3,824 \times 10^{-3}t^3 + 0,2931t^2 - 10,13t + 195,7$	0,9976	20...70	[75]	[72]
	0,5	$\varepsilon = 2,333 \times 10^{-3}t^3 - 0,24t^2 + 6,221t + 34,73$	1,0	20...50	[75]	[72]
NaCl – фосфатный буфер (0,05 M) NaCl – phosphate buffer (0.05 M)	0	$\varepsilon = -6,378 \times 10^{-4}t^2 - 0,1867C + 83,71$	0,9929	7...65	[81]	[78]
	0,5	$\varepsilon = -1,002 \times 10^{-3}t^2 - 0,1343C + 81,09$	0,9931	7...65		
	0,75	$\varepsilon = -1,049 \times 10^{-3}t^2 - 0,1601C + 81,51$	0,9919	7...65		
	1	$\varepsilon = -1,121 \times 10^{-3}t^2 - 0,1562C + 81,15$	0,9922	7...65		
Галактоза-вода Galactose-water	3,48	$\varepsilon = -0,3636t + 87,243$	0,9998	5...40	[31]	[23]
	6,72	$\varepsilon = -0,366t + 86,571$	0,9998	5...40		
	9,75	$\varepsilon = -0,3702t + 86,093$	0,9998	5...40		
	12,6	$\varepsilon = -0,3667t + 85,425$	0,9999	5...40		
	15,27	$\varepsilon = -0,3902t + 84,993$	0,9999	5...40		
	17,78	$\varepsilon = -0,379t + 84,529$	0,9999	5...40		
Глицин-вода Glycine-water	7,33	$\varepsilon = -9,647 \times 10^{-4}t^2 - 0,3216t + 109,8$	0,998	0...50	[1]	[1]
Глюкоза-вода Glucose-water	3,48	$\varepsilon = -0,3605t + 86,836$	0,9999	5...40	[31]	[23]
	6,72	$\varepsilon = -0,3536t + 85,843$	0,9997			
	9,75	$\varepsilon = -0,3517t + 85,0$	0,9999			
	12,6	$\varepsilon = -0,3536t + 84,343$	0,9997			
	15,27	$\varepsilon = -0,35t + 83,575$	0,9997			

Продолжение на следующей странице
Continued on next page



Продолжение таблицы 3
Table 3. (Continued)

Раствор Solution	Концентрация, масс. % Concentration, % w/w	Уравнение Equation	R ²	Диапазон температур, °C Temperature range, °C	Источник	References
Глюкоза-вода Glucose-water	17,78	$\varepsilon = -0,3429t + 82,689$	0,9995	5...40	[31]	[23]
ДМСО-вода DMSO-water	40	$\varepsilon = -0,3845t + 83,633$	0,9997	5...35	[74]	[71]
ДМФА-вода DMFA-water	29,55	$\varepsilon = -0,29t + 70,56$	0,9997	20...40	[18]	[10]
МАц-вода MAc-water	41,73	$\varepsilon = 8,615 \times 10^{-4}t^2 - 0,3387t + 97,46$	0,9915	5...45	[26]	[18]
	57,49	$\varepsilon = 3,9 \times 10^{-3}t^2 - 0,582t + 104,6$	0,999			
	80,23	$\varepsilon = 3,801 \times 10^{-3}t^2 - 0,8614t + 129,5$	0,9998			
Метанол-вода Methanol-water	34	$\varepsilon = 2,485 \times 10^{-3}t^2 - 0,3293t + 67,02$	0,9886	-22...18	[20]	[12]
	50	$\varepsilon = 5,788 \times 10^{-4}t^2 - 0,3564t + 64,81$	0,9903	5...35	[1, 41, 74]	[1, 33, 71]
Сахароза – агар-гель (1%) Sucrose – agar gel (1%)	10	$\varepsilon = 2,202 \times 10^{-5}t^3 - 3,254 \times 10^{-3}t^2 + 1,696 \times 10^{-2}t + 71,14$	0,9939	10...60	[83]	[80]
	20	$\varepsilon = 2,293 \times 10^{-4}t^3 - 2,468 \times 10^{-2}t^2 + 0,7437t + 54,57$	0,9703			
	30	$\varepsilon = -1,442 \times 10^{-4}t^3 + 1,002 \times 10^{-2}t^2 - 2,922 \times 10^{-2}t + 53,81$	0,9678			
	40	$\varepsilon = 1,998 \times 10^{-4}t^3 - 2,197 \times 10^{-2}t^2 + 0,904t + 25,42$	0,9966			
Сахароза-вода Sucrose-water	5	$\varepsilon = 9,781 \times 10^{-4}t^2 - 0,4222t + 86,51$	0,9998	0...100	[1, 83]	[1, 80]
	10	$\varepsilon = 7,889 \times 10^{-4}t^2 - 0,4059t + 85,38$	0,9989			
	20	$\varepsilon = 6,833 \times 10^{-4}t^2 - 0,3911t + 82,45$	0,9966			
	30	$\varepsilon = 5,113 \times 10^{-4}t^2 - 0,3684t + 79,32$	0,9971			
	40	$\varepsilon = 5,351 \times 10^{-4}t^2 - 0,3652t + 76,45$	0,9991			
ФА-вода FA-water	33,41	$\varepsilon = -0,378t + 103,8$	0,9997	20...40	[18]	[10]
Этанол-вода Ethanol-water	95	$\varepsilon = 2,998 \times 10^{-3}t^2 + 0,04805t + 38,4$	0,9998	-156...-110	[50]	[42]
	99	$\varepsilon = 5,455 \times 10^{-3}t^2 + 0,7786t + 84,34$	0,9973	-162...-119		
ЭГ-вода EG-water	20	$\varepsilon = 9,493 \times 10^{-4}t^2 - 0,4203t + 82,93$	0,9991	-10...100	[70, 80, 82, 106]	[65, 77, 79, 104]
	30	$\varepsilon = 9,181 \times 10^{-4}t^2 - 0,4116t + 79,7$	0,9994	-10...100		
	40	$\varepsilon = 6,727 \times 10^{-4}t^2 - 0,3394t + 74,32$	0,9986	-20...100	[80, 106]	[77, 104]
	50	$\varepsilon = 1,052 \times 10^{-3}t^2 - 0,4116t + 72,9$	0,9996	-20...100	[70, 77, 80, 82, 106]	[65, 74, 77, 79, 104]
	60	$\varepsilon = 9,555 \times 10^{-4}t^2 - 0,3787t + 68,0$	0,9979	-40...100	[80, 106]	[77, 104]
	80	$\varepsilon = 1,23 \times 10^{-3}t^2 - 0,3012t + 55,46$	0,9953	-15...100		

Литература

- Ахадов Я.Ю. Диэлектрические свойства бинарных растворов. – М.: Наука, 1977. – 400 с.
- Ахадов Я.Ю. Диэлектрические свойства чистых жидкостей. – М.: Изд-во стандартов, 1972. – 412 с.

References

- Akhadov Y.Y. Dielectric Properties of Binary Solutions. Moscow: Nauka; 1977.
- Akhadov Y.Y. Dielectric Properties of pure liquids. Moscow: Izdatelstvo standartov; 1972.



3. Журавлев А.В., Суслев В.И., Тарасенко П.Ф. Выбор модели диэлектрической релаксации вещества для измеренных спектров смеси метилового спирта и воды на основе проверки гипотез // Известия высших учебных заведений. Физика. – 2010. – Т. 53, №9/3. – С. 279–280.
4. Журавлев В.И., Усачева Т.М. Равновесные диэлектрические свойства бутандиолов // Вестник Московского университета. Серия: Химия. – 2010. – Т. 51, №4. – С. 274–278.
5. Карапетян Ю.А., Эйчис В.М. Физико-химические свойства электролитных неводных растворов. – М.: Химия, 1989. – 256 с.
6. Лифанова Н.В., Усачева Т.М., Бахилина Н.В. и др. Диэлектрические свойства системы 1,2-пропандиол – бензол // Вестник Московского университета. Серия: Химия. – 1998. – Т. 39, №1. – С. 33–36.
7. Марковский Ю.Е., Зори А.А. Применение радиочастотного метода для анализа компонентного состава жидких смесей и водных растворов органических диэлектриков // Наук. праці ДонНТУ. – 2010. – Вип. 171. – С. 212–217.
8. Москалец А.П. Разработка моделей надмолекулярной организации и физико-химических свойств жидких растворов: Автореф. дис. ... канд. физ.-мат. наук. – Москва, 2010. – 29 с.
9. Справочник химика. Т. 1. / Под. ред. Б.П. Никольского. – М. – Л.: Химия, 1966. – 1072 с.
10. Статическая диэлектрическая проницаемость воды и водяного пара в состоянии насыщения [Электронный документ] // [веб-сайт] http://twf.mpei.ac.ru/tthb/2/OIVT/HB_v201/GLAVA3/Table3_6.pdf (11.06.2014).
11. Akode C.G., Kanse K.S., Lokhande M.P. et al. Dielectric relaxation studies of aqueous sucrose in ethanol mixtures using time domain reflectometry // *Pramana – J. Phys.* – 2004. – Vol. 62, №4. – P. 973–981.
12. Alshami A.S. Dielectric properties of biological materials: a physical-chemical approach: A dissertation ... PhD. – Washington, 2007. – 173 p.
13. Anopchenko A., Psurek T., VanderHart D. et al. Dielectric study of the antiplasticization of trehalose by glycerol // *Phys. Rev.* – 2006. – Vol. 74, Pt. 3, Pt. 1 – P. 031501–1–031501–10.
14. Archer D.G., Wang P. The dielectric constant of water and Debye-Hackel limiting law stopes // *J. Phys. Chem. Ref. Data*, 1990. – Vol. 19, №2. – P. 371–411.
15. Baudot A., Bret J.L. A simple capacitive cell for the measurement of liquids dielectric constant under transient thermal conditions // *CryoLetters*. – 2003. – Vol. 24, №1. – P. 5–16.
16. Bhat J.I., Manjunatha M.N. Studies on the effect of dielectric constant on the solvation behaviour of citric acid as a function of temperature // *Arch. Appl. Sci. Res.* – 2011. – Vol. 3, №5. – P. 362–380.
17. Bhatti N.K. Heterogeneous electron transfer rate constants of some substituted bipyridinium halides: A dissertation ... PhD. – Islamabad, 2002. – 250 p.
18. Bittelli M., Flury M., Roth K. Use of dielectric spectroscopy to estimate ice content in frozen porous media // *Water Resour. Res.* – 2004. – Vol. 40, №4. – P. 1–11.
19. Bolund B.F., Berglund M., Bernhoff H. Dielectric study of water-methanol mixtures for use in pulsed-power water capacitors // *J. Appl. Phys.* – 2003. – Vol. 93, №5. – P. 2895–2899.
20. Bordini F., Cametti C. Colby R.H. Dielectric spectroscopy and conductivity of polyelectrolyte solutions // *J. Phys. Condens. Matter*. – 2004. – Vol. 16, №49. – P. R1423–R1463.
21. Brennan T.V., Clarke S. Spontaneous degradation of polypeptides at aspartyl and asparaginyl residues: Effects of the solvent dielectric // *Protein Sci.* – 1993. – Vol. 2, №3. – P. 331–338.
22. Bruno T.J., Svoronov P.D.N Handbook of basic tables for chemical analysis. – Boca Raton: CRC Press, 2010. – 887 p.
23. Buck D.E. The dielectric spectra of ethanol-water mixtures in the microwave region: A dissertation ... PhD. – Massachusetts, 1965. – 71 p.
24. Buckley F., Maryott A.A. Tables of dielectric dispersion data for pure liquids and dilute solutions // US Department of com-
3. Akode C.G., Kanse K.S., Lokhande M.P. et al. Dielectric relaxation studies of aqueous sucrose in ethanol mixtures using time domain reflectometry. *Pramana J Phys* 2004; 62(4): 973–981.
4. Alshami A.S. Dielectric properties of biological materials: a physical-chemical approach [dissertation]. Washington state university, 2007.
5. Anopchenko A., Psurek T., VanderHart D. et al. Dielectric study of the antiplasticization of trehalose by glycerol. *Phys Rev* 2006; 74(3, Pt.1): 1–10.
6. Aragonés J.L., MacDowell L.G., Vega C. Dielectric constant of ices and water: a lesson about water interactions. *J Phys Chem. A*. 2011; 115(23): 5745–5758.
7. Archer D.G., Wang P. The dielectric constant of water and Debye-Hackel limiting law stopes. *J Phys Chem Ref Data* 1990; 19(2): 371–411.
8. Baudot A., Bret J.L. A simple capacitive cell for the measurement of liquids dielectric constant under transient thermal conditions. *CryoLetters* 2003; 24(1): 5–16.
9. Bhat J.I., Manjunatha M.N. Studies on the effect of dielectric constant on the solvation behaviour of citric acid as a function of temperature. *Arch Appl Sci Res* 2011; 3(5): 362–380.
10. Bhatti N.K. Heterogeneous electron transfer rate constants of some substituted bipyridinium halides [dissertation]. Islamabad, 2002.
11. Bittelli M., Flury M., Roth K. Use of dielectric spectroscopy to estimate ice content in frozen porous media. *Water Resour Res* 2004; 40(4): 1–11.
12. Bolund B.F., Berglund M., Bernhoff H. Dielectric study of water-methanol mixtures for use in pulsed-power water capacitors. *J Appl Phys* 2003; 93(5): 2895–2899.
13. Bordini F., Cametti C. Colby R.H. Dielectric spectroscopy and conductivity of polyelectrolyte solutions. *J Phys Condens Matter* 2004; 16(49): R1423–R1463.
14. Brennan T.V., Clarke S. Spontaneous degradation of polypeptides at aspartyl and asparaginyl residues: Effects of the solvent dielectric. *Protein Sci* 1993; 2(3): 331–338.
15. Bruno T.J., Svoronov P.D.N Handbook of basic tables for chemical analysis. Boca Raton: CRC Press; 2010.
16. Buck D.E. The dielectric spectra of ethanol-water mixtures in the microwave region [dissertation]. Massachusetts Institute of Technology, 1965.
17. Buckley F., Maryott A.A. Tables of dielectric dispersion data for pure liquids and dilute solutions. US Department of commerce. National Bureau of Standart. Circular 589. Available from: www.boulder.nist.gov/div838/SelectedPubs/NBS%20Circular%20589.pdf [cited 5.06.2014].
18. Butler R.A. Electrolyte behavior in solvents of high dielectric constant [dissertation]. University of Florida, 1978.
19. Caleman C., van Maaren P.J., Hong M. et al. Force field benchmark of organic liquids: density, enthalpy of vaporization, heat capacities, surface tension, isothermal compressibility, volumetric expansion coefficient, and dielectric constant. *J Chem Theory Comput* 2012; 8(1): 61–74.
20. Chaudhari H.C., Chaudhari A., Mehrotra S.C. Dielectric study of aqueous solutions of alanine and phenylalanine. *J Chin Chem Soc* 2005; 52(1): 5–10.
21. Chavan S., Kumbharkhane A., Mehrotra S. Microwave dielectric behaviour of 1,2-propanediol – water mixture studied using time domain reflectometry technique. *J Chin Chem Soc* 2007; 54(6): 1457–1462.
22. Chen H.-I., Chang H.-Y. Homogeneous precipitation of cerium dioxide nanoparticles in alcohol/water mixed solvents. *Colloids and Surfaces A: Physicochem Eng Aspects* 2004; 242(1–3): 61–69.
23. Chen Y.-J., Zhuo K.-L., Kang L. Dielectric constants for binary saccharide-water solutions at 278.15–313.15 K. *Acta Phys Chim Sin* 2008; 24(1): 91–96.
24. Chitra R., Smith P.E. Molecular dynamics simulations of the properties of cosolvent solutions. *J Phys Chem* 2000; 104(24): 5854–5864.
25. Cohn E.J., McMeekin T.L., Blanchard M.H. Studies in the physical chemistry of amino acids, peptides, and related substan-



- merce. National Bureau of Standart. Circular 589 [Электронный документ] // [веб-сайт] www.boulder.nist.gov/div838/SelectedPubs/NBS%20Circular%20589.pdf (5.06.2014).
26. Butler R.A. Electrolyte behavior in solvents of high dielectric constant: A dissertation... Ph.D. University of Florida. – 1978. – 124 p.
 27. Caleman C., van Maaren P.J., Hong M. et al. Force field benchmark of organic liquids: density, enthalpy of vaporization, heat capacities, surface tension, isothermal compressibility, volumetric expansion coefficient, and dielectric constant // *J. Chem. Theory Comput.* – 2012. – Vol. 8, №1. – P. 61–74.
 28. Chaudhari H.C., Chaudhari A., Mehrotra S.C. Dielectric study of aqueous solutions of alanine and phenylalanine // *J. Chin. Chem. Soc.* – 2005. – Vol. 52, №1. – P. 5–10.
 29. Chavan S., Kumbharkhane A., Mehrotra S. Microwave dielectric behaviour of 1,2-propanediol-water mixture studied using time domain reflectometry technique // *J. Chin. Chem. Soc.* – 2007. – Vol. 54, №6. – P. 1457–1462.
 30. Chen H.-I., Chang H.-Y. Homogeneous precipitation of cerium dioxide nanoparticles in alcohol/water mixed solvents // *Colloids and Surfaces A: Physicochem. Eng. Aspects.* – 2004. – Vol. 242, №1–3. – P. 61–69.
 31. Chen Y.-J., Zhuo K.-L., Kang L. Dielectric constants for binary saccharide-water solutions at 278.15–313.15 K // *Acta Phys. Chim. Sin.* – 2008. – Vol. 24, №1. – P. 91–96.
 32. Chitra R., Smith P.E. Molecular dynamics simulations of the properties of cosolvent solutions // *J. Phys. Chem.* – 2000. – Vol. 104, №24. – P. 5854–5864.
 33. Cohn E.J., McMeekin T.L., Blanchard M.H. Studies in the physical chemistry of amino acids, peptides, and related substances. XI. The solubility of cystine in the presence of ions and another dipolar ion // *J. Gen. Physiol.* – 1938. – Vol. 21, №5. – P. 651–663.
 34. Cole R.H., Davidson D.W. Dielectric properties of trimethylene glycol // Brown university, ONR Contract Nonr-562(03), NR-051–284, 1953. – P. 28–36.
 35. Common organic solvents: table of properties [Электронный документ] // [веб-сайт] www.wuestgroup.com/Solvent%20Properties.pdf (16.04.2014).
 36. CRC Handbook of chemistry and physics. – Boca Raton: CRC Press, 2005. – 2661 p.
 37. Daneshvari D. Investigation of binary polar solvent mixtures, solubilized ferroelectric salts and Paraffin-based derivatives using dielectric spectroscopy: A dissertation ... Ph.D. – Basel, 2007. – 294 p.
 38. Davidson D.W. The dielectric properties of methanol and methanol-d // *Can. J. Chem.* – 1957. – Vol. 35, №5. – P. 458–473.
 39. Dielectric constant of common materials [Электронный документ] // [веб-сайт] www.flowmeterdirectory.com/dielectric_constant_01.html (16.07.2014).
 40. Douheret G., Morenas M. Thermodynamic and physical behaviour of some water + polyethyleneglycol mixtures. II. Dielectric properties // *Can. J. Chem.* – 1979. – Vol. 57, №6. – P. 608–613.
 41. Emara M.M., Shehata H.A., Elnhaily S. Thermodynamics of ion-association of NaClO₄ in aqueous-methanol and aqueous-glycerol using conductance measurement // *J. Chin. Chem. Soc.* – 1988. – Vol. 35, № 5. – P. 337–344.
 42. Experimental aspects [Электронный документ] // [веб-сайт] <http://pr.hec.gov.pk/chapters/346S-3.pdf> (28.06.2014).
 43. Fabbri A., Fen-Chong T., Coussy O. Dielectric capacity, liquid water content, and pore structure of thawing-freezing materials // *Cold Reg. Sci. Technol.* – 2006. – Vol. 44, №1. – P. 52–66.
 44. Faraji M., Farajtabar A., Gharib F. Determination of water-ethanol mixtures autoprotolysis constants and solvent effect // *J. Appl. Chem. Res.* – 2009. – Vol 9, №1. – P. 7–12.
 45. Farjtabar A. Application of electrochemistry to determination of transfer gibbs energies and autoprotolysis constants for aqueous mixtures of dimethyl sulfoxide // *J. Appl. Chem. Res.* – 2012. – Vol. 20, №1. – P. 28–35.
 46. Feng Y., Yu Z.-W., Quinn P.J. Effect of urea, dimethylurea, and tetramethylurea on the phase behavior of dioleoylphosphatidylethanolamine // *Chem. Phys. Lipids.* – 2002. – Vol. 114, №2. – P. 149–157.
 47. ces. XI. The solubility of cystine in the presence of ions and another dipolar ion. *J. Gen. Physiol.* 1938; 21(5): 651–663.
 26. Cole R.H., Davidson D.W. Dielectric properties of trimethylene glycol. Brown university, ONR Contract Nonr-562(03), NR-051–284, 1953. p. 28–36.
 27. Common organic solvents: table of properties Available from: www.wuestgroup.com/Solvent%20Properties.pdf [cited 16.04.2014].
 28. CRC Handbook of chemistry and physics. Boca Raton: CRC Press, 2005.
 29. Daneshvari D. Investigation of binary polar solvent mixtures, solubilized ferroelectric salts and Paraffin-based derivatives using dielectric spectroscopy [dissertation]. Basel, 2007.
 30. Davidson D.W. The dielectric properties of methanol and methanol-d. *Can J Chem* 1957; 35(5): 458–73.
 31. Dielectric constant of common materials Available from: www.flowmeterdirectory.com/dielectric_constant_01.html [cited 16.07.2014].
 32. Douheret G., Morenas M. Thermodynamic and physical behaviour of some water + polyethyleneglycol mixtures. II. Dielectric properties. *Can J Chem* 1979; 57(6): 608–613.
 33. Emara M.M., Shehata H.A., Elnhaily S. Thermodynamics of ion-association of NaClO₄ in aqueous-methanol and aqueous-glycerol using conductance measurement. *J Chin Chem Soc* 1988; 35(5): 337–344.
 34. Experimental aspects Available from: <http://pr.hec.gov.pk/chapters/346S-3.pdf> (accessed on 28.06.2014).
 35. Fabbri A., Fen-Chong T., Coussy O. Dielectric capacity, liquid water content, and pore structure of thawing-freezing materials. *Cold Reg Sci Technol* 2006; 44(1): 52–66.
 36. Faraji M., Farajtabar A., Gharib F. Determination of water-ethanol mixtures autoprotolysis constants and solvent effect. *J Appl Chem Res* 2009; 9(1): 7–12.
 37. Farjtabar A. Application of electrochemistry to determination of transfer gibbs energies and autoprotolysis constants for aqueous mixtures of dimethyl sulfoxide. *J Appl Chem Res* 2012; 20(1): 28–35.
 38. Feng Y., Yu Z.-W., Quinn P.J. Effect of urea, dimethylurea, and tetramethylurea on the phase behavior of dioleoylphosphatidylethanolamine. *Chem Phys Lipids* 2002; 114(2): 149–157.
 39. Gaiduk V.I., Tseitlin B.M., Vij J.K. Orientational/translational relaxation in aqueous electrolyte solutions: a molecular model for microwave/far-infrared ranges. *Phys Chem Chem Phys* 2001; 3(4): 523–534.
 40. Gavish N., Promislow K. Dependence of the dielectric constant of electrolyte solutions on ionic concentration Available from: <http://arxiv.org/pdf/1208.5169v1.pdf> [cited 29.06.2014].
 41. Gomaa E.A., Al-Jahdali B.A.M. Electrochemical studies on the interaction of cadmium ion with kryptofix 22 in MeOH-DMF solutions at different temperatures. *Sci Technol* 2012; 2(4): 66–76.
 42. Hassion F.X., Cole R.H. Dielectric properties of liquid ethanol and 2-propanol. Brown university, ONR Contract Nonr-562(03), NR-051-284: p. 1–27.
 43. Hasted J.B., Ritson D.M., Collie C.H. Dielectric properties of aqueous ionic solutions. Parts I and II. *J Chem Phys* 1948; 16(1): 1–21.
 44. Hernandez-Luis F., Galleguillos-Castro H., Estes M.A. Activity coefficients of NaF in aqueous mixtures with ϵ -increasing cosolvent: formamide-water mixtures at 298.15K. *Fluid Phase Equilib* 2005; 227(2): 245–253.
 45. Hernandez-Perni M.E. A Contribution to the understanding of percolation phenomena in binary liquids [dissertation]. Basel, 2004.
 46. Hobbs M.E., Jhon M.S., Eyring H. The dielectric constant of liquid water and various forms of ice according to significant structure theory. *PNAS* 1966; 56(1): 31–38.
 47. Karapetyan Y.A., Eychis V. Physical-chemical properties of the electrolyte non-aqueous solutions. Moscow: Khimia; 1989.
 48. Khalil M.I., Al-Resayes S.I. The role of dielectric constant in sodium chloride solution chemistry: Magnitude of super saturation. *Int J Phys Sci* 2012; 7(4): 578–583.
 49. Knecht L.A. N-methylacetamide: purification and tests for purity. *Pure Appl Chem* 1971; 27(1–2): 281–290.



47. Gaiduk V.I., Tseitlin B.M., Vij J.K. Orientational/translational relaxation in aqueous electrolyte solutions: a molecular model for microwave/far-infrared ranges // *Phys. Chem. Chem. Phys.* – 2001. – Vol. 3, №4. – P. 523–534.
48. Gavish N., Promislow K. Dependence of the dielectric constant of electrolyte solutions on ionic concentration [Электронный документ] // [веб-сайт] <http://arxiv.org/pdf/1208.5169v1.pdf> (29.06.2014).
49. Gomaa E.A., Al-Jahdali B.A.M. Electrochemical studies on the interaction of cadmium ion with kryptofix 22 in meoh-dmf solutions at different temperatures // *Sci. Technol.* – 2012. – Vol. 2, №4. – P. 66–76.
50. Hassion F.X., Cole R.H. Dielectric properties of liquid ethanol and 2-propanol // Brown university, ONR contract nonr-562(03), NR-051. – 284. – P. 1–27.
51. Hasted J.B., Ritson D.M., Collie C.H. Dielectric properties of aqueous ionic solutions. Parts I and II // *J. Chem. Phys.* – 1948. – Vol. 16, №1. – P. 1–21.
52. Hernandez-Luis F., Galleguillos-Castro H., Esteso M.A. Activity coefficients of NaF in aqueous mixtures with ϵ -increasing co-solvent: formamide-water mixtures at 298.15K // *Fluid Phase Equilib.* – 2005. – Vol. 227, №2. – P. 245–253.
53. Hernandez-Perni M.E. A Contribution to the understanding of percolation phenomena in binary liquids: A dissertation ... PhD. – Basel, 2004. – 193 p.
54. Hobbs M.E., Jhon M.S., Eyring H. The dielectric constant of liquid water and various forms of ice according to significant structure theory // *PNAS.* – 1966. – Vol. 56, №1. – P. 31–38.
55. Khalil M.I., Al-Resayes S.I. The role of dielectric constant in sodium chloride solution chemistry: Magnitude of super saturation // *Int. J. Phys. Sci.* – 2012. – Vol. 7, №4. – P. 578–583.
56. Knecht L.A. N-methylacetamide: purification and tests for purity // *Pure Appl. Chem.* – 1971. – Vol. 27, №1–2. – P. 281–290.
57. Koizumi N., Hanai T. Dielectric constants of some alcohols at low frequencies // *B. Inst. Chem. Res.* – 1955. – Vol. 33, №1. – P. 14–20.
58. Koizumi N., Hanai T. Dielectric properties of polyethylene glycols: dielectric relaxation in solid state // *B. Inst. Phys. Res.* – 1964. – Vol. 42, №2–3. – P. 115–127.
59. Lee J.M., Jhon M.S., Eyring H. Significant structure theory applied to electrolyte solution // *PNAS.* – 1979. – Vol. 76, №11. – P. 5421–5423.
60. Lu Z., Manias E., Macdonald D.D. et al. Dielectric relaxation in dimethyl sulfoxide/water mixtures studied by microwave dielectric relaxation spectroscopy // *J. Phys. Chem. A.* – 2009. – Vol. 113, №44. – P. 12207–12214.
61. Macdonald J.R. Analysis of dielectric and conductive dispersion above T_g in glass-forming molecular liquids // *J. Phys. Chem. B.* – 2008. – Vol. 112, №44. – P. 13684–13694.
62. Mali C.S., Chavan S.D., Kanse K.S. et al. Dielectric relaxation of poly ethylene glycol – water mixtures using time domain technique // *Indian J. Pure Appl. Phys.* – 2007. – Vol. 45, №5. – P. 476–481.
63. Malmberg C.G., Maryott A.A. Dielectric constants of aqueous solutions of dextrose and sucrose // *J. Res. Natl. Inst. Stan.* – 1950. – Vol. 45, №4. – P. 299–303.
64. Malmberg C.G., Maryott A.A. Dielectric constant of water from 0 to 100°C // *J. Res. Natl. Inst. Stan.* – 1956. – Vol. 56, №1. – P. 1–8.
65. Marshall W.L. Dielectric constant of water discovered to be simple function of density over extreme ranges from –35 to +600°C and to 1200 MPa (12000 Atm.), Believed Universal [Электронный документ] // [веб-сайт] [<http://precedings.nature.com/documents/2478/version/1/files/npre20082472-1.pdf>] (22.05.2014).
66. Maryott A.A., Smith E.R. Table of dielectric constants of pure liquids // United States department of commerce, National bureau of standards. Circular 514 [Электронный документ] // [веб-сайт] [www.boulder.nist.gov/div838/SelectedPubs/NBS%20Circular%20514.pdf] (19.05.2014).
67. Mason W.A., Shutt W.J. The dielectric capacity of electrolytes in mixed solvents: ion association in solutions of magnesium
50. Koizumi N., Hanai T. Dielectric constants of some alcohols at low frequencies. *Bull Inst Chem Res* 1955; 33(1): 14–20.
51. Koizumi N., Hanai T. Dielectric properties of polyethylene glycols: dielectric relaxation in solid state. *Bull Inst Phys Res* 1964; 42(2–3): 115–127.
52. Lee J.M., Jhon M.S., Eyring H. Significant structure theory applied to electrolyte solution. *PNAS* 1979; 76(11): 5421–5423.
53. Lifanova N.V., Usacheva T.M., Bakhilina N.V. et al. Dielectric properties of the propane-1,2-diol-benzene system. *Vestnik Moskovskogo universiteta. Khimia.* 1998; 39(1): 33–36
54. Lu Z., Manias E., Macdonald D.D. et al. Dielectric relaxation in dimethyl sulfoxide/water mixtures studied by microwave dielectric relaxation spectroscopy. *J Phys Chem A* 2009; 113(44): 12207–12214.
55. Macdonald J.R. Analysis of dielectric and conductive dispersion above t_g in glass-forming molecular liquids. *J Phys Chem B* 2008; 112(44): 13684–13694.
56. Mali C.S., Chavan S.D., Kanse K.S. et al. Dielectric relaxation of poly ethylene glycol – water mixtures using time domain technique. *Indian J. Pure Appl. Phys.* 2007; 45(5): 476–481.
57. Malmberg C.G., Maryott A.A. Dielectric constants of aqueous solutions of dextrose and sucrose. *J Res Natl Inst Stan* 1950; 45(4): 299–303.
58. Malmberg C.G., Maryott A.A. Dielectric constant of water from 0 to 100C. *J. Res. Natl. Inst. Stan.* 1956; 56(1): 1–8.
59. Markovskyy Y.E., Zori A.A. Use of RF-method for the analysis of component composition of solutions and mixtures of liquid organic dielectrics. *Scientific Papers of Donetsk National Technical University.* 2010; (171): 212–217
60. Marshall W.L. Dielectric constant of water discovered to be simple function of density over extreme ranges from - 35 to + 6000C and to 1200 MPa (12000 Atm.), Believed Universal Available from: <http://precedings.nature.com/documents/2478/version/1/files/npre20082472-1.pdf> [cited 22.05.2014].
61. Maryott A.A., Smith E.R. Table of dielectric constants of pure liquids // United States department of commerce, National bureau of standards. Circular 514 Available from: www.boulder.nist.gov/div838/SelectedPubs/NBS%20Circular%20514.pdf [cited 19.05.2014].
62. Mason W.A., Shutt W.J. The dielectric capacity of electrolytes in mixed solvents: ion association in solutions of magnesium sulphate. *Proc R Soc Lond A* 1940; 175(961): 234–253.
63. Matsuoka T., Okada T., Murai K. et al. Dynamics and hydration of trehalose and maltose in concentrated solution. *J Mol Liq* 2002; 98–99: 317–327.
64. McDuffie G.E., Quinn R.G., Litovitz T.A. Dielectric properties of glycerol-water mixtures. *J Chem Phys* 1962; 37(2): 239–242.
65. MEGlobal. Ethylene. Available from: www.meglobal.biz/products-literature [cited 9.06.2014].
66. Mohsen-Nia M., Amiri H. Measurement and modelling of static dielectric constants of aqueous solutions of methanol, ethanol and acetic acid at $T=293.15$ K and 91.3 kPa. *J Chem Thermodynamics* 2013; 57: 67–70.
67. Moscalets A.P. Development of models of supramolecular organization and physico-chemical properties of liquid solutions [dissertation]. Moscow; 2010.
68. Nagarajan R., Wang C.-C. Theory of surfactant aggregation in water/ethylene glycol mixed solvents. *Langmuir* 2000; 16(12): 5242–5251.
69. Nikolsky B.P. editor. Handbook of chemist. Vol. 1. Moscow-Leningrad: Khimia; 1966.
70. Olmi R., Meriakr V.V., Ignesti A. et al. Dielectric spectroscopy of sugar and ethanol solutions in water for monitoring alcoholic fermentation processes. *J Microwave Power E E* 2007; 41(3): 38–50.
71. O'Reilly N.J., Magner E. Electrochemistry of cytochrome c in aqueous and mixed solvent solutions: thermodynamics, kinetics, and the effect of solvent dielectric constant. *Langmuir* 2005; 21(3): 1009–1014.
72. Orellana L. Immobilized enzymes: time temperature indicators for dielectric pasteurization processes [dissertation]. Washington State University, 2004.



- sulphate // Proc. R. Soc. Lond. A. – 1940. – Vol. 175, №961. – P. 234–253.
68. Matsuoka T., Okada T., Murai K. et al. Dynamics and hydration of trehalose and maltose in concentrated solution // J. Mol. Liq. – 2002. – Vol. 98–99. – P. 317–327.
69. McDuffie G.E., Quinn R.G., Litovitz T.A. Dielectric properties of glycerol-water mixtures // J. Chem. Phys. – 1962. – Vol. 37, №2. – P. 239–242.
70. MEGlobal. Ethylene [Электронный документ] // [веб-сайт] [www.meglobal.biz/products-literature] (9.06.2014).
71. Mohsen-Nia M., Amir H. Measurement and modelling of static dielectric constants of aqueous solutions of methanol, ethanol and acetic acid at T=293.15 K and 91.3 kPa // J. Chem. Thermodynamics. – 2013. – Vol. 57. – P. 67–70.
72. Nagarajan R., Wang C.-C. Theory of surfactant aggregation in water/ethylene glycol mixed solvents // Langmuir. – 2000. – Vol. 16, №12. – P. 5242–5251.
73. Olmi R., Meriakr V.V., Ignesti A. et al. Dielectric spectroscopy of sugar and ethanol solutions in water for monitoring alcoholic fermentation processes // J. Microwave Power E. E. – 2007. – Vol. 41, №3. – P. 38–50.
74. O'Reilly N.J., Magner E. Electrochemistry of cytochrome c in aqueous and mixed solvent solutions: thermodynamics, kinetics, and the effect of solvent dielectric constant // Langmuir. – 2005. – Vol. 21, №3. – P. 1009–1014.
75. Orellana L. Immobilized enzymes: time temperature indicators for dielectric pasteurization processes: A dissertation ... PhD. Washington State University. – 2004. – 207 p.
76. Pathak R.N., Saxena I., Mishra A. et al. Study of the influence of alkyl chain cation – solvent interactions on water structure in 1,3-butanediol – water mixture by apparent molar volume data // J. Chem. – 2011. – Vol. 8, № 3. – P. 1323–1329.
77. Pelagic meg/water umbilical flushing and storage fluids [Электронный документ] // [веб-сайт] [www.subseafluids.com/pdfs/Umbilical_Storage_fuids/Pelagic_MEG.Water/Pelagic_MEG-Water_Manual.pdf] (7.06.2014).
78. Physical properties of glycerine and its solutions. ACI Science. American Cleaning Institute [Электронный документ] // [веб-сайт] [www.aciscience.org/does/Physical_properties_of_glycerine_and_its-solutions.pdf] (17.05.2014).
79. Pure component properties [Electronic document] // [web-site] [www.ddbst.com/en/EED/PCP/PCPindex.php] (1.07.2014).
80. Rao N.S.S.V.R. Studies on solute-solvent interactions in ionic liquid systems: A dissertation ... PhD. – Visakhapatnam, 2013. – 282 p.
81. Raviyan P., Tang J., Orellana L. et al. Physicochemical properties of a time-temperature indicator based on immobilization of aspergillus oryzae – amylase in polyacrylamide gel as affected by degree of cross-linking agent and salt content // J. Food Sci. – 2003. – Vol. 68, №7. – P. 2302–2308.
82. Roy R.N., Baker G.E., Hoffman T., Breithaupt E.L., Roy L.N. Standard electrode potentials of silver-silver chloride electrodes in 20, 30, and 50% (w/w) ethylene glycol/water from 250C to –200C pK2 and pH* values of the physiological buffer "BES" in 50 % (w/w) ethylene glycol/water // CryoLetters. – 1988. – Vol. 9, № 3. – P. 172–185.
83. Sakai N., Mao W., Koshima Y. et al. A method for developing model food system in microwave heating studies // J. Food Eng. – 2005. – Vol. 66, №4. – P. 525–531.
84. Saleh J.M., Khalil M., Hokmat N.A. Investigation of some physical properties of glycerol– water mixtures at 298.15 K // J. Iraqi Chem. Soc. – 1986. – Vol. 11, №1. – P. 89–104.
85. Sarkar B.K., Roy M.N., Sinha B. Conductance studies on some alkali metal acetates in aqueous glycerol solutions // Indian J. Chem. – 2009. – Vol. 48A, № 1. – P. 63–68.
86. Sarode A.V., Kumbharkhane A.C. Chain length effect on dielectric relaxation and thermo-physical behaviour of organic polymers through relaxation dynamics using TDR // Int. J. Basic Appl. Res. – 2012. – Special volume. – P. 220–225.
87. Schwer C., Kenndler E. Electrophoresis in fused-silica capillaries: the influence of organic solvents on the electroosmotic
73. Pathak R.N., Saxena I., Mishra A. et al. Study of the influence of alkyl chain cation-solvent interactions on water structure in 1,3-butanediol-water mixture by apparent molar volume data. J Chem 2011; 8(3): 1323–1329.
74. Pelagic meg/water umbilical flushing and storage fluids Available from: www.subseafluids.com/pdfs/Umbilical_Storage_fuids/Pelagic_MEG.Water/Pelagic_MEG-Water_Manual.pdf [cited 7.06.2014].
75. Physical properties of glycerine and its solutions. ACI Science. American Cleaning Institute. Available from: www.aciscience.org/does/Physical_properties_of_glycerine_and_its-solutions.pdf [cited 17.05.2014].
76. Pure component properties. Available from: [www.ddbst.com/en/EED/PCP/PCPindex.php] [cited 1.07.2014].
77. Rao N.S.S.V.R. Studies on solute-solvent interactions in ionic liquid systems [dissertation]. Visakhapatnam, 2013.
78. Raviyan P., Tang J., Orellana L. et al. Physicochemical properties of a time-temperature indicator based on immobilization of aspergillus oryzae-amylase in polyacrylamide gel as affected by degree of cross-linking agent and salt content. J Food Sci 2003; 68(7): 2302–2308.
79. Roy R.N., Baker G.E., Hoffman T., Breithaupt E.L., Roy L.N. Standard electrode potentials of silver-silver chloride electrodes in 20, 30, and 50 % (w/w) ethylene glycol/water from 250C to –200C pK2 and pH* values of the physiological buffer "BES" in 50 % (w/w) ethylene glycol/water. CryoLetters 1988; 9(3): 172–185.
80. Sakai N., Mao W., Koshima Y. et al. A method for developing model food system in microwave heating studies. J Food Eng 2005; 66(4): 525–531.
81. Saleh J.M., Khalil M., Hokmat N.A. Investigation of some physical properties of glycerol- water mixtures at 298.15 K. J Iraqi Chem Soc 1986; 11(1): 89–104.
82. Sarkar B.K., Roy M.N., Sinha B. Conductance studies on some alkali metal acetates in aqueous glycerol solutions. Indian J Chem 2009; 48A(1): 63–68.
83. Sarode A.V., Kumbharkhane A.C. Chain length effect on dielectric relaxation and thermo-physical behaviour of organic polymers through relaxation dynamics using TDR. Int J Basic Appl Res 2012; Special volume: 220–225.
84. Schwer C., Kenndler E. Electrophoresis in fused-silica capillaries: the influence of organic solvents on the electroosmotic velocity and the potential. Anal Chem 1991; 63(17): 1801–1807.
85. Seedher N., Bhatia S. Solubility enhancement of cox-2 inhibitors using various solvent systems. AAPS Pharm Sci Tech 2003; 4(3): 1–9.
86. Sengwa R.J. A comparative dielectric study of ethylene glycol and propylene glycol at different temperatures. J Mol Liq 2003; 108(1–3): 47–60.
87. Sengwa R.J., Choudhary S., Khatri V. Microwave dielectric spectra and molecular relaxation in formamide-N,N-dimethylformamide binary mixtures. Spectrochim Acta A 2011; 82(1): 279–282.
88. Sengwa R.J., Khatri V., Choudhary S. Temperature dependent static dielectric constant and viscosity behaviour of glycerol-amide binary mixtures: Characterization of dominant complex structures in dielectric polarization and viscous flow processes. J Mol Liq 2010; 154(2–3): 117–123.
89. Sengwa R.J., Khatri V., Sankhla S. Dielectric behaviour and hydrogen bond molecular interaction study of formamide-dipolar solvents binary mixtures. J. Mol. Liq. 2009; 144(1–2): 89–96.
90. Sengwa R.J., Khatri V., Sankhla S. Structure and hydrogen bonding in binary mixtures of N,N-dimethylformamide with some dipolar aprotic and protic solvents by dielectric characterization. Ind. J. Chem. 2009; 48A(4) 512–519.
91. Sengwa R.J., Sankhla S. Characterization of heterogeneous interaction in binary mixtures of ethylene glycol oligomer with water, ethyl alcohol and dioxane by dielectric analysis. J Mol Liq 2007; 130(1–3): 119–131.
92. Shigire S.D., Talware R.B., Kadam S.S. et al. Dielectric relaxation of d-sorbitol-water mixtures using a Time Domain Reflectometry Technique. J Mol Liq 2012; 169: 33–36.



- velocity and the potential // *Anal. Chem.* – 1991. – Vol. 63, №17. – P. 1801–1807.
88. Seedher N., Bhatia S. Solubility enhancement of cox-2 inhibitors using various solvent systems // *AAPS Pharm. Sci. Tech.* – 2003. – Vol. 4, № 3. – P. 1–9.
 89. Sengwa R.J. A comparative dielectric study of ethylene glycol and propylene glycol at different temperatures // *J. Mol. Liq.* – 2003. – Vol. 108, №1–3. – P. 47–60.
 90. Sengwa R.J., Choudhary S., Khatri V. Microwave dielectric spectra and molecular relaxation in formamide–N,N-dimethylformamide binary mixtures // *Spectrochim. Acta A.* – 2011. – Vol. 82, №1. – P. 279–282.
 91. Sengwa R.J., Khatri V., Choudhary S. Temperature dependent static dielectric constant and viscosity behaviour of glycerol–amide binary mixtures: Characterization of dominant complex structures in dielectric polarization and viscous flow processes // *J. Mol. Liq.* – 2010. – Vol. 154, №2–3. – P. 117–123.
 92. Sengwa R.J., Khatri V., Sankhla S. Dielectric behaviour and hydrogen bond molecular interaction study of formamide–dipolar solvents binary mixtures // *J. Mol. Liq.* – 2009. – Vol. 144, №1–2. – P. 89–96.
 93. Sengwa R.J., Khatri V., Sankhla S. Structure and hydrogen bonding in binary mixtures of N,N-dimethylformamide with some dipolar aprotic and protic solvents by dielectric characterization // *Ind. J. Chem.* – 2009. – Vol. 48A, №4. – P. 512–519.
 94. Sengwa R.J., Sankhla S. Characterization of heterogeneous interaction in binary mixtures of ethylene glycol oligomer with water, ethyl alcohol and dioxane by dielectric analysis // *J. Mol. Liq.* – 2007. – Vol. 130, №1–3. – P. 119–131.
 95. Shirgire S.D., Talware R.B., Kadam S.S. et al. Dielectric relaxation of d-sorbitol – water mixtures using a Time Domain Reflectometry Technique // *J. Mol. Liq.* – 2012. – Vol. 169. – P. 33–36.
 96. Synthetic glycerine – dielectric constant [Электронный документ] // [веб-сайт] [www.dow.com/optim/optim-advantage/physical-properties/dielectric.htm] (1.06.2014).
 97. Tommila E., Murto M.-L. The influence of the solvent on reaction velocity. XXIII. The alkaline hydrolysis of ethyl acetate in dimethyl sulphoxide – water mixtures // *Acta Chem. Scand.* – 1963. – Vol. 17, №7. – P. 1947–1956.
 98. Tsai C. S. Spontaneous decarboxylation of oxalacetic acid // *Can. J. Chem.* – 1967. – Vol. 45, № 8. – P. 873–880.
 99. Uematsu M., Franck E.U. Static dielectric constant of water and steam // *J. Phys. Chem. Ref. Data.* – 1980. – Vol. 9, №4. – P. 1291–1306.
 100. Undre P.B., Khirade P.W., Rajenimbalkar V.S. et al. Dielectric relaxation in ethylene glycol – dimethyl sulfoxide mixtures as a function of composition and temperature // *J. Korean Chem. Soc.* – 2012. – Vol. 56, №4. – P. 416–423.
 101. Wang P., Anderko A. Computation of dielectric constants of solvent mixtures and electrolyte solutions // *Fluid Phase Equilib.* – 2001. – Vol. 186, №1–2. – P. 103–122.
 102. Wear J.O. Apparatus for dielectric constant measurements and measurements for water-methanol mixtures // *Arkansas Acad. Sci. Proc.* – 1970. – Vol. 24, №1. – P. 80–83.
 103. Wohlfart C. Static dielectric constants of pure liquids and binary liquid mixtures. – Berlin, New York: Springer Science & Business Media, 2008. – 203 p.
 104. Yilmaz H. Excess properties of alcohol-water systems at 298.15 K // *Turk. J. Phys.* – 2002. – Vol. 26, №3. – P. 243–246.
 105. Yoon G. Dielectric properties of glucose in bulk aqueous solutions: Influence of electrode polarization and modeling // *Biosens. Bioelectron.* – 2011. – Vol. 26, №5. – P. 2347–2353.
 106. Zahn M., Ohki Y., Fenneman D.B. et al. Dielectric properties of water and water/ethylene glycol mixtures for use in pulsed power system design // *Proc. IEEE.* – 1986. – Vol. 74, №9. – P. 1182–1236.
 93. Static dielectric constant of water and steam at saturation condition Available from: http://twf.mpei.ac.ru/tthb/2/OIVT/ HB_v201/GLAVA3/Table3_6.pdf [cited 11.06.2014].
 94. Synthetic glycerine – dielectric constant Available from: www.dow.com/optim/optim-advantage/physical-properties/dielectric.htm [cited 1.06.2014].
 95. Tommila E., Murto M.-L. The influence of the solvent on reaction velocity. XXIII. The alkaline hydrolysis of ethyl acetate in dimethyl sulphoxide – water mixtures. *Acta Chem Scand* 1963; 17(7): 1947–1956.
 96. Tsai C. S. Spontaneous decarboxylation of oxalacetic acid. *Can. J. Chem.* 1967; 45(8): 873–880.
 97. Uematsu M., Franck E.U. Static dielectric constant of water and steam. *J. Phys. Chem. Ref. Data* 1980; 9(4): 1291–1306.
 98. Undre P.B., Khirade P.W., Rajenimbalkar V.S. et al. Dielectric relaxation in ethylene glycol – dimethyl sulfoxide mixtures as a function of composition and temperature. *J Korean Chem Soc* 2012; 56(4): 416–423.
 99. Wang P., Anderko A. Computation of dielectric constants of solvent mixtures and electrolyte solutions. *Fluid Phase Equilib* 2001; 186(1–2): 103–122.
 100. Wear J.O. Apparatus for dielectric constant measurements and measurements for water-methanol mixtures. *Arkansas Acad Sci Proc* 1970; 24(1): 80–83.
 101. Wohlfart C. Static dielectric constants of pure liquids and binary liquid mixtures. Berlin, New York: Springer Science & Business Media, 2008.
 102. Yilmaz H. Excess properties of alcohol-water systems at 298.15 K. *Turk J Phys* 2002.; 26(3): 243–246.
 103. Yoon G. Dielectric properties of glucose in bulk aqueous solutions: Influence of electrode polarization and modeling. *Biosens. Bioelectron.* 2011; 26(5): 2347–2353.
 104. Zahn M., Ohki Y., Fenneman D.B. et al. Dielectric properties of water and water/ethylene glycol mixtures for use in pulsed power system design. *Proc IEEE* 1986; 74(9): 1182–1236.
 105. Zhuravlev A.V., Susliaev V.I., Tarasenko P.F. Selection of the model of substance dielectric relaxation for measured spectrums of the mixture of methyl alcohol and water on the basis of testing hypotheses. *Izvestia Vischih Uchebnih Zavedeniy Fizika.* 2010; 53(9–3): 279–80.
 106. Zhuravlev V.I., Usacheva T.M. Equilibrium dielectric properties of butanediols. *Moscow Univ Chem Bull* 2010; 65(4): 225–228.

