FEATURES OF THE STRUCTUREANDPROPERTIES OF WATERIN THE LIQUIDAGGREGATESTATE

ABSTRACT

Waterwasandremains the mostunusualsubstanceonEarth.Untilveryrecently, the structureandabnormalproperties of water have causedheateddiscussionsamongbothdomesticandforeignscientists of differentgenerations.Thisisprimarily due to the complexity of the object of study, the ability of water, evenwithminorexternalinfluences, to easilytransitionfromonemetastablestatetoanother. Of course, thestate of waterat the triplepoint in thephasediagram is of particularinterest.Inthisregard, thepaperconsiders the featuresin the pressure-temperaturecoordinates of somesubstancesin the liquidaggregatestate. The authorshypothesizedthatallsubstancesin the liquidaggregatestateshouldhavecommonfeatures,despitetheiroriginalindividuality. It seems to usthat a universalfeature that unitesallpossibleaggregatestates of wateris the ability of thesystems under consideration to smoothlytransitionfrom a homogeneous to aheterogeneousstate,from a single-phase to atwo-ormorephasesystem,characterized by the appearance of a phaseinterfaceundercertainconditions,thatis, the formation of a dispersedsystem. It is emphasizedintheworkthatuntilnow, whenanalyzing the transitions of waterfromoneaggregatestatetoanother,thetimefactor of the existenceofaphaseinequilibriumormetastablestates, as wellasthetime of existence of thedispersedsystem itself, has not been taken into account. The rapiddevelopmentofwatersciences has ledto the discovery of uniqueproperties of waterinextremeconditions, for example, the ability of waternot to freezeevenwithultra-deep cooling,muchlower than the freezing point of liquidnitrogen,or the experimentallyprovenfactthatat-68°Cwateractsas a mixture of twoliquids of differentdensitiesandothers.Furtheradvancesin the study of the propertiesandconditions of water are inevitablyassociatedwith the convergence of naturalsciences.

Comment [U1]: Check the tense

Keywords:water,oil,liquid,aggregatestate,diagram,structure,loose,relaymechanism,rheology,viscosity,fluidity,dispersedsystem,phaseinterface,timefactor,extremeconditions,ultra-deep cooling,convergence

Introduction

Liquidwaterisoneof the mostvaluableandat the sametime the mostmysteriousmineralsonEarth[1]. The veryexistence of the structure of liquidwaterand the transformation of itspropertiesunder the influence of externalinfluencesstillcausesacutediscussionamongscientists from differentcountries. It is reasonable to assumethatwaterandanyothersubstancesin a liquidaggregatestateshouldhavesomecommonfeaturescharacteristicofthisaggregatestate.Thisstatementfullyappliestooil. The viscosity of oil is moreobviousthanitsfluidity[2].Andforwater, on the contrary,fluidity is a morestrikingsign.Viscosityandfluidity are oneof the mainparametersinrheology. It is knownthatrheologystudies the deformativebehavior of onlystructuredmedia,whereviscosityandfluidity are amongthemostcharacteristicstructural and mechanicalindicators.Inthisregard, it is simplyimpossible to deny the existence of a waterstructure.However, the ability of watertoultrafast,almostinstantaneousrearrangements of the structure of moleculesensuresitsfluidityevenundertheweakestexternalinfluences.This is due to

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itsunusualsensoryproperties. The influence of externalinfluencesonstructuraltransformationsinwater is reflectedin[3-9].

It is knownthatbothwaterandoiltend to formassociatesorclustersat the molecularlevel that exhibitfractalproperties[10-16].However, the formation of associates does notnecessarilymean the presence of a phaseboundary(GRF)betweenthemand the rest of the volume of wateroroil,asoneof the most importantfeatures of a dispersedsystem.Butundercertainconditions, a phaseboundaryappearsbetween the associatesand,as a result,adispersedsystem is formed.Thus,clusterscanform a dispersedphase.Thishappenswhen, forcertainreasons, clustersreachcolloidalsizesfrom1to100nm,forming a singlephaseeitherinvolumeoron the surface. It is knownthat the diameter of watermoleculescorresponds to about0.3nm,and the clustertotalityincludesfrom30to1012molecules[6]. The lowerlimitcorresponds to the minimumpossiblephase line in the liquidaggregatestate, which has a phaseinterfacewithgaseousandotherexistingphases.Thus,bothwaterandoilcan be consideredasdispersedsystemsundercertainconditions.Figure1shows a diagram of the phasestate of wateraccording to K.Krauskopf,fromwhich it followsthatwaterin a liquidaggregatestateexistsintheOCA region,inthiscase we are talkingabout a homogeneous single-phasesystem.

Comment [U3]: Please define GRF

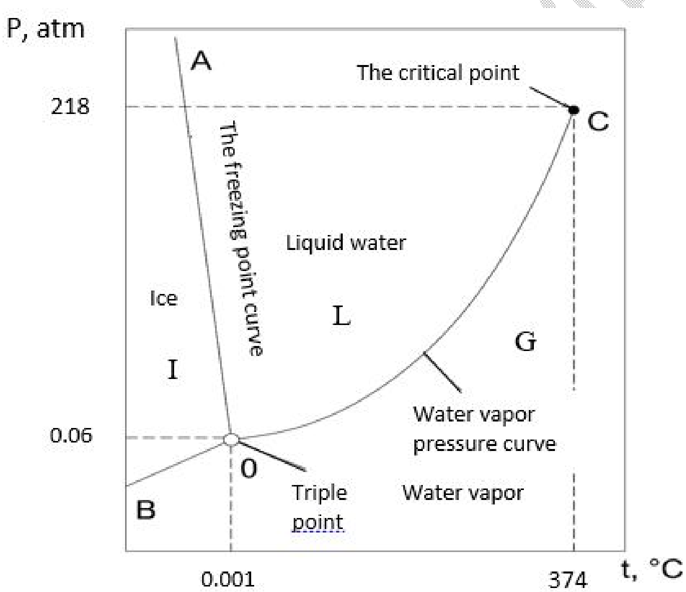

Fig.1.Diagram of the phasestate of water(according to K.Krauskopf)

At the triplepointOthree,aggregatestates of watercanbeinequilibrium.It is the onlysubstancewiththisproperty.At the criticalpointC, waterpassesfrom a homogeneous to aheterogeneoussystem,from a single-phase to a two-phase one,with the occurrence of a GRFbetweengasandliquid. The peculiarity of thisstateisthatnotgas(steam)dissolvesinwater,butwaterdissolvesingas,waterturnsfrom a polar to a non-polarliquid.Wateralsohasspecialpropertiesatcharacteristicpointsт AandB. A homogeneousstate of water is possibleonlyatpointsI,L,G.Recently, manyworks have appeared[16-20]on the studyandrefinement of the phasediagram of waterin terms ofitstransitionfrom a liquidaggregatestate to asolid one. It has been experimentallyestablishedthat a quasi-liquid filmexistson the surface of dispersediceparticles. It is shownthat the nucleation of a condensedphaseinwatervapor is observedon the nanostructuredsurface of icecrystals.Asshownin[18], 19newforms of ice have recently been discovered.Similarprocessesprobablyoccurduring the transition of liquidwater to avaporousstate.All of the abovesuggeststhattheKrauskopfstatediagram,inouropinion,onlyapproximatesthephenomena under consideration.It is knownthat at almostanypressureandtemperatureabovewater, it is alwayspossible to

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detectanddetermine the presence of a gasphase(steam).Inouropinion, the presence of twophases is typicalforotheraggregatestates.

As shown in Fig. 2, between the liquid and gaseous phases there must be some transitional state of transformation of water from liquid to gaseous state (II), as well as from liquid to solid (region I) and from solid to gaseous (region III).

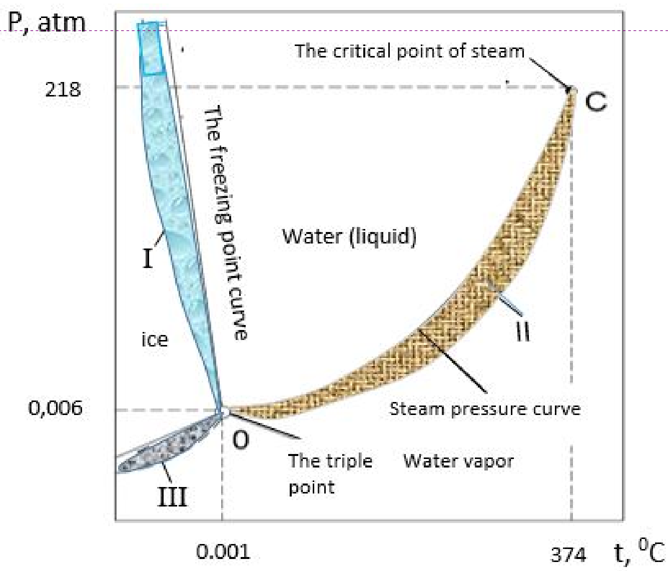

Fig.2.Diagram of the state of water

It can be arguedthat the transition from oneaggregatestatetoanotherisnotabrupt,butsmooth and gradual.Thisassumption is confirmed by the well-knownfactthat"fast"molecules are alwayspresentat the surface of iceorliquid,which, flyingout of the solidorliquidphase,formeithersteamor a liquidwith a certainpartialpressure.AdispersedsystemwithGRFarises in the transitionregions. The processes of watertransitionfrom a homogeneous to aheterogeneousstatecan be conditionallydesignated by the scheme:homogeneous→heterogeneous→homogeneous.Thesespontaneoustransitionscanoccurbothin the forwardandin the oppositedirections.It should be particularlynotedthatsofar the timefactor of the existenceofaphasein an equilibriumormetastablestate has not been taken into account intheprocesses under consideration.Fromthesepositions,evenat the triplepoint, it is more correct to speaknotabout the simultaneousexistence of threephases,butabout the continuoustransition of solid,liquid, and gaseousphasesintoeach other with a characteristictransitiontime.Thus, the formation of a dispersedsystemis a commonobligatorysign of the transition of waterfrom a homogeneoussystem to aheterogeneous one,and from a single-phase to amultiphase one. A distinctivefeature of wateristhatitis a single-componentsystem,unlikeoil,whichisamulticomponentmixture.

Manyparadoxes of waterstill do nothave a clearphysicalinterpretation, andtodayonlyonetheory of A.V.Kochetkov[21]tries to explainthembasedon the hypothesisof the existence of somemolecularphotonicmediumthat is capable of suppressingintermolecularinteractions of waterin a liquidstate.Thermalphotonsinintermolecularspace are preciselysuch a medium,andtheyarenotordinarymatter,butonly being locatedin an intramoleculargridcansuppresselectromagneticbondsbetweenmolecules.This is A.V.Kochetkovexplainsoneof the mostmysteriousproperties of water-itsfluidity.Inouropinion,thermalphotons are ablenot so much to suppressintermolecularbondsas to accelerate the process of the relaymechanism[22] of transferring a hydrogenatomalongintermolecularbonds.

Comment [U6]: Do well to acknowledge the source if its not your work.

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The oilstatediagraminpressure-temperaturecoordinateshas a loop-like appearance(Fig.3),thatis, it differsfrom the phasediagram of anypure single-componentsubstance,includingwater.

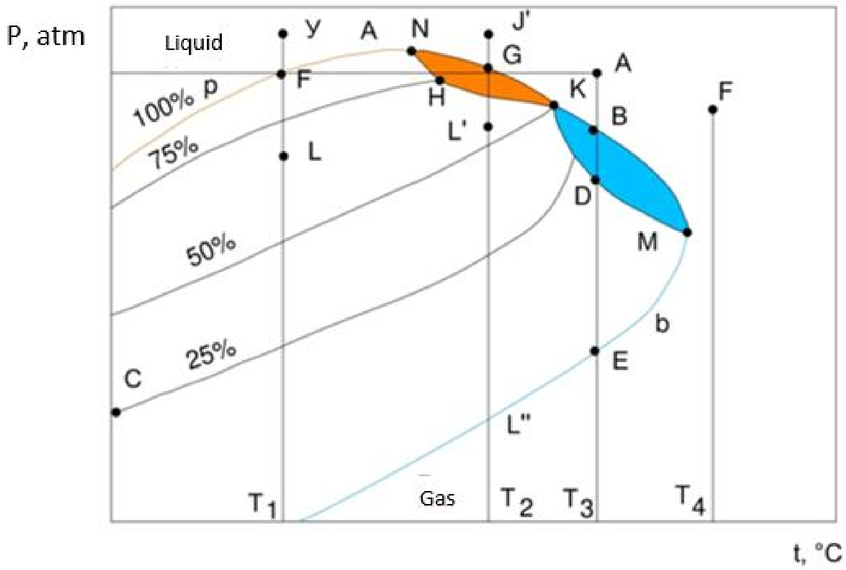

Fig.3.Phasediagram of a multicomponentmixture

AtpointK(Fig.3), the so-calledcriticalpoint, the pressureandtemperaturevaluescorrespond to a specialstatewhen the properties of eachphasebecomeidentical.AtpointsA,B,M,N,aswell as in the retrogradeanddiffusionregions,oilactsas a dispersedsystem.At the sametime, the association of molecules of oilcomponents does notmeanthattheyalwaysform a dispersedsystem. The associates are evenlydistributedin the liquidand, most importantly, there is nointerfacebetweenthemand the freemolecules.Butinthissystem, aso-calledsupramolecularstructure arises,which is inmany ways similar to the properties of a dispersedsystem,butitisnot.Andattheabovepoints,oilbehaveslike a trulydispersedsystem, the hallmark of whichis the mandatorypresence of GRF.Thus,oil, as wellaswater, tends to moverelativelyeasilyfromhomogeneoustoheterogeneous,from a single-phaseto a multiphasesystem.Thismeansthat the ability of waterandoil to form a dispersedsystemis a commonuniversalproperty of theobjects under consideration in the liquidaggregatestate.

Regardingwater, it should be notedthatabsolutelypurewater does notexistinnature. It is necessary to distinguish between the so-called"computer"water,i.e.idealwaterconsistingofhydrogenandoxygenatomsortheirisotopes,forwhichtheKrauskopfstatediagram is valid.Inreality, atleastoneimpurityparticleexistsin the water.It does notaffecttheaggregatestate of water,but the role of theseimpurities is special,sincetheirpresencegeneratesattractiveandrepulsiveforcesbetweenwaterparticles,whichmeans that it contributes to the appearance of the supramolecularstructure of water, as wellasaqueoussolutions. The abnormalproperties of wateralsoclearlyindicatethepresence of a waterstructure.Moreover, without the latter, the verypresence of anomalies is impossible.

We have previouslyshown[23]thatwaterhas a loosestructure:approximately61-63% of the volume of oneliter of water is occupied by voids.Theworkshowsthat in addition to water,atomicandmoleculargases,aswell as manyorganiccompounds, haveloosestructures.Moreover, with an increase in the molecularweight of organiccompounds, the friabilitydecreases.Andamong the atomicgases, hydrogen is especiallydistinguishedfromall the elements of the D.I.Mendeleevtable,whichforms an abnormallysuperdensestructure.Atthesametime,

Comment [U10]: You can begin this sentence with another word outside "and" molecularhydrogenandheliumformloosestructures.Thisspecialproperty of atomichydrogenseems to have a globalsignificance(Tables1,2).

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Table1.Change in the volumeratio(V) of watermoleculesandvoidswith a change in radius(R) from1.30to1.64nm

R, $\times 10^{-10}$ м	V, см^3
1,30	307,73
1,32	322,15
1,34	337,02
1,36	352,33
1,38	368,11
1,40	381,97
1,40	384,35
1,42	401,05
1,44	418,24
1,46	435,91
1,48	454,07
1,50	472,73
1,52	491,89
1,54	511,56
1,56	531,75
1,58	552,47
1,60	573,72
1,64	618,03

Comment [U12]: Use -9 to represent nanoscale

Comment [U13]: Please use the "dot" sign to indicate fractions eg 307.73

As can be seenfromTable1,with a radiusof1.64x10-10m, the volume of voidsis618.03cm3,whichexactlycoincideswith the goldenratio. It is interesting to notethatformeltwater, the clusterstructure of the watermoleculeforms a so-calledgoldentrianglewith a goldennumber of 0.618034at a vertex of 108°.

Comment [U14]: Check the exponent value for "nano" value. Moreso, use superscript

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Table2.Indicators of the friability of the structure of organiccompounds

Substances	R, 10^{-10} м	V, см^3
CH_4	0,190	1080,990
C_3H_8	0,215	569,566
C_4H_{10}	0,215	679,318
C_2H_4	0,195	667,770
C_3H_6	0,225	683,880
C_4H_8	0,280	988,470

C_6H_{12}	0,335	1128,59

As can be seenfromTable2,withincreasingmolecularweight, the looseness of the structures as awholealso increases

Comment [U16]: Please use dots (.) instead of comma (,) to indicate fractions

Inouropinion, the structure of waterisgenerallysimilar to the structure of the galaxyor the entireuniverse as awhole. The universealsohas a loosestructure,likeanyobject that is an integralpart of it. The processes that take placeinwaterinmoments take placein the universeovermillionsandbillions of years.At the same time, the dynamics of processesinwaterandspace,inouropinion, are of the same type. When we studyspace,westudywaterand vice versa. It can be arguedthatwateris a kind of hologram of the universe.In the works of [24-26]GribovaL.A. For the first time, the problem was formulated"whynatureprovides for the possibility of the existence of a huge(up to a million)number of structuralisomersofthesamegrosscomposition."At the same time, the most importantprocessesin the molecularworld,according to GribovL.A.,are"processesinwhich the initiallyaccumulatedenergy(signal) is thentransmitted in a directedmannertoanotherisolatedpart of the molecularspacesothateithersignificantchanges in the molecularstructureoccurinthisplace of space,or the appearance of a newsubstance,initiallynotin the system that existed."Inouropinion,similarprocessesoccurbothinwaterandinaqueoussolutions,bothunder the influence of naturalandartificialexternalfactors.Inwater,inouropinion, the number of structuralisomers of the composition is equivalent to the number of metastablestatesintowhichwater is able to transitionundergiventhermodynamicconditions of existence.

Comment [U17]: This is not clear please

A comprehensive~~comprehensive~~study of physics,chemistry,mechanicsandbiology of waterisjustbeginning.Manyproperties of waterinextremeconditions have not yet been sufficientlystudied. For example, the recentdiscovery of the ability of waternot to freezeunderultra-deep cooling,muchlower than the freezing point of liquidnitrogen, is ofparticularinterest.Suchwaterretainsitsliquidstatein the so-calledlipidfat micro-reservoirs.Anotherimportantdiscoveryover the lastperiodis the proof of the existence of twoandmultistructuralmodels of waterundercertainconditions. It has been experimentallyprovedthatat-68°C, wateractsas a mixture of twoliquidswithdifferentdensities,differinginthisindicatorfromeach other by about20percent.At the same time, thesearetwoliquids that do notmixwitheach other,betweenwhichthere is a GRF,whichmeans that a dispersedsystemarises,with a liquiddispersionmediumand a liquiddispersedphase.

Waterstillholdsmanymysteries, the keyto the discovery of which is inevitablyconnectedwith the convergence of sciences,primarilyphysics,chemistryandmathematics.

The body of the work has no subtitle, just introduction.

Kindly break the work into sections/subsections.

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