MYSTERIES OF CHEMICAL PHYSICS

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Abstract: The article provides several examples of mysterious scientific facts and physicochemical phenomena that have a nontrivial scientific explanation obtained both with the help of special calculations and with the help of original experiments. Possible reasons for the following facts and phenomena are considered: specific composition of the Earth's atmosphere and specific chirality of biological molecules; dependence of the rate of chemical reactions in a solid on the magnitude of shear strain; unique features of the glassy state of matter during glass–liquid transitions and during plastic deformation; the existence of materials with negative Poisson's ratio; the existence of conditions under which the diffusion mode of the occurrence of chemical transformations is technologically more beneficial than the kinetic mode; an unusually high order of the polymerization rate of the trioxane formaldehyde cyclic trimer in terms of the trioxane concentration (up to 7!); and high strength of natural polymer materials (wood).

Keywords: terrestrial atmosphere; chirality of biological molecules; the rate of reaction in a solid; shear deformation; glassy state of matter; plastic deformation; diffusion reaction mode; polymerization; strength

DOI: 10.30826/CE20130301

Figure Captions

Figure 1 Forest fire

Figure 2 Schematic of the macromolecular helicity induction on poly-q upon complexation with L-alanine [1]

Figure 3 Schematic of Bridgman's laboratory anvil

Figure 4 Polyacrylamide yield vs. the angle of rotation of the anvils at a temperature of 393 K and pressure of 1 (*1*), 2 (*2*), 2.5 (*3*), and 36 Pa (*4*) [3]

Figure 5 Schematic of a single-screw (*a*) and twin-screw (*b*) extruders

Figure 6 Jumps in density and transition temperature variation as functions of the difference in disk sizes predicted by two-dimensional (2D) (*a*) and three-dimensional (3D) (*b*) computational models: *1* — Lennard–Jones potential; *2* — rigid discs

Figure 7 The model of 7 rigid disks on the plane [5]: R is the all radius; r is the disk radius; from left to right: $T = 0$, $0 < T < T_{\mathrm{tr}}$, $T = T_{\mathrm{tr}}$ (T_{tr} is the melting/vitrification)

Figure 8 Molecular-dynamic simulation of plastic deformation with the Lennard–Jones potential: (*a*) 2D; and (*b*) 3D

Figure 9 Spatial distribution of local deformations of the various stages of uniaxial compression of the system of ellipsoidal disks

Figure 10 Calculated dependences of the reduced shear stress (*a*), volume variation (*b*), and mean number of contact (*c*) on the shear deformation ε at the uniaxial compression of the system of ellipsoidal disks [7]

Figure 11 Spatial distributions of local deformations (*a*), disks with a small number of contats (marked in a dark color (*b*), and the directions of all disk contacts in the sample (*c*) at the stage of plastic deformation (shown by the arrow) [7])

Figure 12 Electron micrographs of polyester foam (*a*, *b*) and porous copper (*c*, *d*) and after (*b*, *e*) triaxial compression [7]

Figure 13 Formaldehyde polymerization

Figure 14 Intramolecular rearragement of carbonium ion

Figure 15 Interaction of carbonium ion with iso-butane

Figure 16 Two options of supplying reactants for alkylation

Figure 17 Schematic of emulsion: (*a*) acid–iso-butane, (*b*) iso-butane–acid; *1* — butylens, *2* — iso-butane, and *3* — acid

Figure 18 Polymer yield vs. initial concentration of trioxane at 60 °C: (*a*) during 35 min in n-heptane; (*b*) during 100 min in cyclohexane; catalyst $BF_3O(C_2H_5)_2$; and $C_{\text{cat}} = 7.5 \cdot 10^{-3}$ mol/l [9]

Figure 19 Schematic of trioxane polymerization: (*a*) at $[M] > [M]_p^l$; and (*b*) at $[M] < [M]_p^l$

Figure 20 Microphotographs of trioxane polymers formed in the solutions of nitrobenzene (*a*, *b*) and methylene cloride (*c*, *d*) at $[M] > [M]_p^l$ (*a*, *c*) and $[M] < [M]_p^l$ (*b*, *d*) [10]

Figure 21 Schemes of chemical potentials of stereoregular (syndio- and isofactic) and irregular (atactic) polymers in two solvents

Figure 22 Dependence of the copolymer composition on the composition of the monometer mixture at various concentrations of trioxane: *1* — 2–4 mol/l; *2* — 0.9–1.2; *3* — 3–4; and *4* — 1.5–1.9 mol/l. Catalyst $BF_3O(C_2H_5)_2$, 25 °C. Solvent: (*a*) nitrobenzene; and (*b*) methylene chloride [10]

Figure 23 Micrographs of trioxane and dioxolane copolymers formed in the solution of methylene chloride at $[M] > [M]_p^l$ (*a*) and $[M] < [M]_p^l$ (*b*) [10]

Table Caption

The order of the reaction rate of trioxane polymerization with respect to the monomer in various solvents n, $W \sim [M]^n$

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Received August 14, 2020

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