The Seminar “Nonlinear Dynamics of Chemical Reactions, Processes, and Reactors” (Cochairmen: Yu.D. Tret'yakov and I.V. Melikhov)

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The regular seminar held on 5 June 2008 was devoted to discussing the role of the agglomeration of primary nano- and microparticles in the formation of dispersed media obtained from oversaturated media. The experimental facts of the possibility to control the transition of crystallizing systems from the nonequilibrium state to the equilibrium state with the view of obtaining nanodispersed materials with assigned characteristics were discussed.

The report “Formation of Ensembles of Oxide and Fluoride Nanoparticles” was made by Professor P.P. Fedorov (Prokhorov Institute of General Physics, Russian Academy of Sciences). The promising approach to synthesizing nanocrystalline materials that are the initial components for obtaining optical monocrystals with improved properties was presented in the report. To obtain nanodispersed oxide and fluoride materials, a two-stage method was developed, at the first stage of which phases (noncrystalline or crystalline) of strongly hydrated salts (borates, nitrates) that were precursors for obtaining the corresponding oxides were formed by precipitation from aqueous solutions. These phases are not stable and pass into the steady state in the course of the subsequent heating due to the nonequilibrium forms of crystalline particles transforming into equilibrium forms. In the last case, it was revealed that this passage could have several stages. Thus, when the precursor of yttrium oxide that morphologically represents crystalline plates with a thickness of 10 nm and a length of approximately 100 nm is heated up to 500°C, the water loss proceeds at several stages; however, the particle form of yttrium oxide remains at all stages (the shape memory effect). The rapid decomposition of plates into isometric ball-shaped particles with a diameter corresponding to the thickness of a plate takes place in the course of the subsequent heating. Analogous phenomena were observed when obtaining nanoparticles of magnesium oxide by the precipitation of magnesium hydroxide plates, during dehydration under heating with the retention of the plate form of particles, and their subsequent decomposition. It follows from

the report that more detailed knowledge about the role played by the processes of crystallization and aggregation of primary nanoparticles would give the opportunity to consciously select the conditions for synthesizing many important nonorganic materials, in particular, for photonics.

When the report was discussed, it was also noted that the approach to the controlled synthesis of nanodispersed materials presented by the reporter could be efficiently used for many substances, taking into consideration that the nonlinearity of the processes manifests itself more distinctively as the requirements on the accuracy in forecasting the conditions of a synthesis increase (I.V. Melikhov and Yu.D. Tret'yakov). The argumentative form was taken up by the discussion regarding the possible mechanisms of the memory shape effect observed for nanoparticles and the phenomenon of the decomposition of precursor plates into isometric nanoparticles (P.E. Kazin and V.N. Rudin, et al). The supposition about the decisive role in the phenomenon of the decomposition of different forms of water contained in the structure of precursors was advanced (Yu.D. Tret'yakov). In this connection, the question has arisen about how important it is to characterize in detail the composition and morphology of the investigated nanosystems by different methods. The question as to in what cases the advantages of using nanodispersed substances as initial raw materials for obtaining monocrystals are realized and as to how their characteristics affect the target properties of optical materials was also discussed (V.E. Bozhevol'nov).

Finishing the seminar, I.V. Melikhov noted that the phenomena considered in the report were very widespread and that the processes underlying them were undoubtedly nonlinear. It is very difficult to describe them, and therefore the results of the experiment admit many interpretations. However, the large quantity of experimental data in the work discussed provides an opportunity for real quantitative modeling.