Cluster Structure of Dissolved Gas Nanobubbles in Ionic Aqueous Solutions

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The aggregation of nanodispersed particles to various spatial structures essentially influences the physical properties of disperse systems, in particular, gas nanobubbles in aqueous solutions. The scattering matrix is known to be sensitive to the shape and size distribution of scatterers. We propose a mathematical approach to modeling the clusters of spherical particles that is based on the approximation of experimental angular dependences of the scattering matrix elements by the theoretical ones, which are calculated as the average over a stochastic cluster ensemble. The hierarchical computational model of fractal growth allowing for cluster-cluster aggregation was elaborated. In this model the fractal dimension of generated random realizations of clusters has monotonic dependence on the model parameter, defining the probability of participation of a cluster in coagulation act according to its volume. The variation of this parameter enables to approximate uniformly the scattering indicatrix within a given angular range. We have applied the method for studying the structure of natural heterogeneity in ionic aqueous solutions with dissolved gases. With the help of the developed program package the inverse light scattering problem of determining the fractal properties of nanobubble clusters in water media was solved. By minimizing the divergence functional for the calculated angular profiles of scattering matrix for the samplings of hierarchical-type clusters and the data of laser scattering experiments it was found that in aqueous 0.8 M solution NaCl the mean number of monomeric nanobubbles in clusters is 420, the effective radius and effective relative width of lognormal size distribution of the monomers are 50 nm and 0.02 respectively, mean fractal dimension D = 2.45.