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ABSTRACT

The dissertation entitled ‘Two- and three-dimensional nanocomposites containing noble metal nanoparticles functionalized with aminothioalkyl ligands’, written by Michalina Iwan, conducted under the scientific supervision of prof. Marcin Fiałkowski, describes the development of synthetic platforms for fabrication of durable 2D nanocomposites with noble metal nanoparticles (NPs) permanently linked with each other, and synthesis of 3D nanocomposite materials with metallic NPs chemically bound to a polymeric matrix. For the synthesis of both 2D and 3D nanocomposites the key was to use NPs functionalized with aminothioalkyl ligands. The 2D nanocomposite consists of a single monolayer of the NPs, chemically cross-linked via covalent bonds, forming a free-standing 2D nanofilm. This monolayer film is durable in air conditions, and maintains its integrity even when unsupported. The obtained 3D nanocomposites are characterized by a homogeneous distribution of the NPs, where covalent bonding between the NPs and the polymeric matrix provides resistance against aggregation of the nanoadditives.

The dissertation provides a description of the developed synthetic procedures of novel organic compounds necessary for the nanocomposite fabrication procedures - (1) surface ligands for the functionalization of NPs, providing NPs with their stability and reactivity, and (2) the cross-linking agent. Furthermore, a facile method of the NP organization at the liquid-liquid interface between two immiscible phases, being a robust synthetic platform for the fabrication of the monolayer NP film, is presented. The process of migration of the NPs from the bulk phase to the interphase is explained, to ensure a high level of control of this NP interfacial self-assembly. The important role of emulsion microdroplets in the process, acting as NP carriers is elucidated. The structural and mechanical properties of the obtained 2D film are analyzed. It is found that after the cross-linking the NPs from fairly densely packed lattices, and the monolayer displays elastic properties. Moreover, synthetic details of 3D nanocomposite production processes are given for nanocomposites having structures based on natural, such as cellulose and starch, and synthetic polymers. The nature of the NP–polymer matrix bonding is investigated, providing evidence of the formation of durable chemical bonds. Finally, a plausible explanation of the role of the NPs as carriers of aminothioalkyl ligands in the process of covalent bond formation between the nanoadditives and nanocomposite matrices is proposed.