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Properties of nanometal-polyaniline composites

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ABSTRACT

Polymeric nanocomposites are intimate combinations of a polymer with inorganic nanoparticles. Such nanomaterials have attracted significant attention over the years because of their potential uses as chemical sensors, electronic and optical devices, and as catalysts. For catalytic applications, in particular, small and well dispersed nanoparticles are desired. We report here the synthesis of gold-polyaniline (AuPANI) nanocomposites and their catalytic performance. The simple synthetic route involved pre-organizing the gold ions in polyaniline (PANI) through complexation followed by the addition of a reducing agent. Control over the degree of reduction of tetrachloroaurate ions ($AuCl_4^-$) depends on the electrochemical potential of the system which in turn depends on the molar ratio of the nitrogen atoms on PANI to $AuCl_4^-$. Gold nanoparticles formed when the AuPANI complexes were reduced with sodium borohydride and the size of the nanoparticles could be varied with adjustment of the amount of sodium borohydride used. Low amounts of sodium borohydride induced slow nucleation rate and were associated with relatively large metallic particles. The smallest gold nanoparticles with a narrow size distribution were obtained when a ratio of sodium borohydride:gold of about 6:1 was used. Simple electrolytes like NaCl and NaOH did not induce the aggregation of Au nanoparticles as predicted by the DLVO theory. However, chain-like aggregates formed when aggregation was induced by the reduction of PANI while close-packed aggregates formed when PANI was oxidized or protonated. The Au nanoparticles were found to be more stable when dispersed on ring-substibuted PANI than on unsubstituted PANI. The catalytic performance of AuPANI was evaluated using the reduction of 4-nitrophenol by sodium borohydride. The reaction was observed to follow the Langmuir-Hinshelwood kinetics.