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Coating Mechanism of Gold Particles onto Sepiolite

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Extended Abstract

Gold nanoparticles (AuNPs), due to their optical properties, have attracted the interest of many researchers and are widely used in many applications such as electronics, photodynamic therapy, sensors, probes, diagnostics catalysis, cosmetics, and nanomedicine etc (Newman and Blanchard 2006; Tiwari et al. 2007; Pecharromán et al. 2009; Zhang et al. 2009; Zhu et al. 2009). AuNPs is a suspension of sub-micron gold particles typically dispersed in water, and the color of the suspension changes from red to other colors including brown, yellow, and purple as the particle size changes (Ung et al. 2001). Moreover, their optical response may change depending on the particle size, shape, and concentration (Kelly et al. 2002).

Sepiolite ($Si_{12}Mg_9O_{30}(OH)_6(OH_2)4H_2O$) is a hydrated magnesium silicate with micro and mesoporous structure. Its fiber morphology and the presence of alternating blocks and tunnels that grow in the fiber direction make it an ideal material for use in particular applications such as viscosity, color, plasticity, dry and fired strength, absorption and adsorption, abrasion and others (Sabah and Çelik 2002; Kara et al. 2003; Ozdemir et al. 2004; Özdemir et al. 2007; Sabah et al. 2007; Çınar et al. 2009).

In this study, the amenability of AuNPs (~16 nm) coating on sepiolite surfaces was studied in detail. First of all, the zeta potential of natural sepiolite (0.1% solid ratio) and AuNPs of 1 ppm as a function of pH was performed using ZetaPlus equipped with the electrophoresis technique (Brookhaven Instrument Corporation USA). De-ionized (DI) water (18 MΩcm) (Milli-Q plus Millipore Ultra PureWater system, Millipore Ltd, Molshem, France) and ambient temperature (22∓ 1°C) were utilized in all measurements.

The zeta potential measurements showed that while a zero point of charge (zpc) of natural sepiolite was obtained around pH 3.2, the AuNPs showed negative charges at all pH values. Meanwhile, the zeta potential of 1 ppm and 25 ppm AuNPs yielded -20.38 mV and 39.86 mV at natural pH, respectively. Interestingly, the 1 and 25 ppm of AuNPs showed no significant coating on the natural sepiolite surfaces, and slightly increased its zeta potential to -17.8 mV and -22.4 mV from -15.75 mV, respectively; this can be attributed to both AuNPs and natural sepiolite surfaces carrying negative charges at natural pH. For this reason, the typical cationic surfactant Hexadecyl Trimetyl Ammonium Bromide (HTAB) purchased from Sigma-Aldrich (purity >99%) was used to modify the sepiolite surfaces to increase AuNPs' coating capacity. The results showed that the surface charge of modified sepiolite decreased to +14.86 mV and

+4.01 mV from +17.52 mV upon treating it with 1 and 25 ppm of AuNPs, respectively. Meanwhile, the suspension color changed from red to blue with increasing amine concentration indicating the increase in the size of gold nanoparticles.

These results in summary indicated the insignificant coating of AuNPs on the natural sepiolite surfaces because both AuNPs and natural sepiolite surfaces are negatively charged at natural pH. However, modification of sepiolite with quaternary amine molecules made the charge positive, and in turn considerably increased the AuNPs coating on sepiolite surfaces due to electrostatic attraction. On the other hand, there was a critical amine concentration which caused precipitation of AuNPs-sepiolite-HTAB composite in the system. These composites are considered as excellent water-processible or bio-compatible materials.

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