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Synthesis of Various Types of Silver Nanoparticles Used as Physical Developing Nuclei in Photographic Science

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Abstract: Ag nanoparticles used as physical developing nuclei in photographic science were prepared by reduction method. The as-formed Ag nanoparticle colloid was characterized by UV-Vis absorption spectrum, Atomic Force Microscopy(AFM) and Charge Coupled Device (CCD) technique. It is found that the source of Ag ions, the addition of surfactant and polymer, all have great influence on the size, topography and catalytic activity of Ag nanoparticles.

Keywords: Ag, nanoparticle, AFM, DTR.

Physical developing process is the key part of silver diffusion transfer reversal (DTR) in photographic science[1]. Its main reaction is that the Ag complexes are reduced to metallic Ag image by reducing agent under catalysis of physical developing nuclei. Metal or metal-sulfide nanoparticles are usually developing nuclei in DTR system, such as Ag, Au, Pt, Ag_2S, PdS, ZnS. The preparation and catalytic activity of various nuclei have attracted considerable attention in the fields of photography[2,3]. In this experiment, Ag was chosen as developing nucleus, the influence of preparation methods on its size, topography and catalytic activity was studied with AFM and CCD technique[4].

Experimental

Synthesis of Ag nanoparticles

Ag nanoparticles were prepared by reduction method under ultrasonic agitation. KBH_4 was the reduction agent. Two Ag ion sources were adopted, one was $AgNO_3$, the other was $Ag(S_2O_3)_2^{3-}$. The Ag colloid was stabilized by cationic surfactant (DPS) and polymer(PDCE), respectively.

The photo absorption spectra of Ag colloid dispersions were measured by a Hitachi U-3000 UV-Vis spectrophotometer. Specimens for AFM observation were prepared by spin-coating method as described in our previous paper[5]. All AFM images were obtained in air using an AutoProbe CP Research Scanning Probe Microscope (Park Scientific Instrument) in tapping mode. The catalytic activity of Ag nanoparticles was

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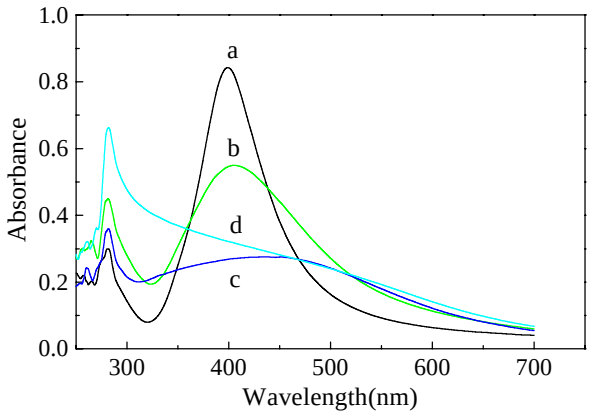
examined by CCD technology.

Results and Discussion

Effect of composition on UV-Vis spectra

UV-Vis absorption spectra have been proved to be quite sensitive to the form of Ag colloids, since Ag nanoparticles exhibit a characteristic absorption peak around 400 nm due to the surface plasmon excitation[6]. **Figure 1** illustrates the absorption spectra of Ag nanoparticles prepared by different methods. It can be seen clearly that the absorption peaks are quite different. For Ag colloid prepared with the addition of DPS, the absorption peak of Ag made from $AgNO_3$ is very sharp, and is broaden and shifted to longer wavelength while made from $Ag(S_2O_3)_2^{3-}$. For Ag colloid added with PDCE, the peak of Ag made from $AgNO_3$ is broadened, but Ag colloid made from $Ag(S_2O_3)_2^{3-}$ doesn't show any characteristic absorption between 200 nm and 700 nm.

Figure 1 UV-vis spectra of Ag colloids



a Ag/DPS($AgNO_3$) b Ag/PDCE ($AgNO_3$)
c Ag/DPS($Ag(S_2O_3)_2^{3-}$) d Ag/PDCE($Ag(S_2O_3)_2^{3-}$)

Effect of composition on AFM topographies

AFM images of **Figure 2** indicate three-dimensional topographies of Ag nanoparticles prepared by different methods. It is apparent that polymer, surfactant and the source of Ag ions all have effect on the size distribution and shape of the particles. For **Figure 2a**, Ag nanoparticles were congregate, almost every Ag nanoparticle of **Figure 2c** was circled with unknown materials, Ag particles of **Figure 2b** and **2d** were well dispersed.

Effect of composition on the catalytic activity

The catalytic activities of various Ag nanoparticles as physical developing nuclei were monitored by CCD instrument. Maximum Ag reflectance was corresponded to the

maximum Ag density and nuclei catalytic activity. **Figure 3** shows that the order of activity of various physical developing nuclei was b>d>a>c. It was found that the presence of polymer could profoundly influence the catalytic activity of Ag nanoparticles in DTR system.

Figure 2 AFM images of Ag nanoparticles prepared with different composition

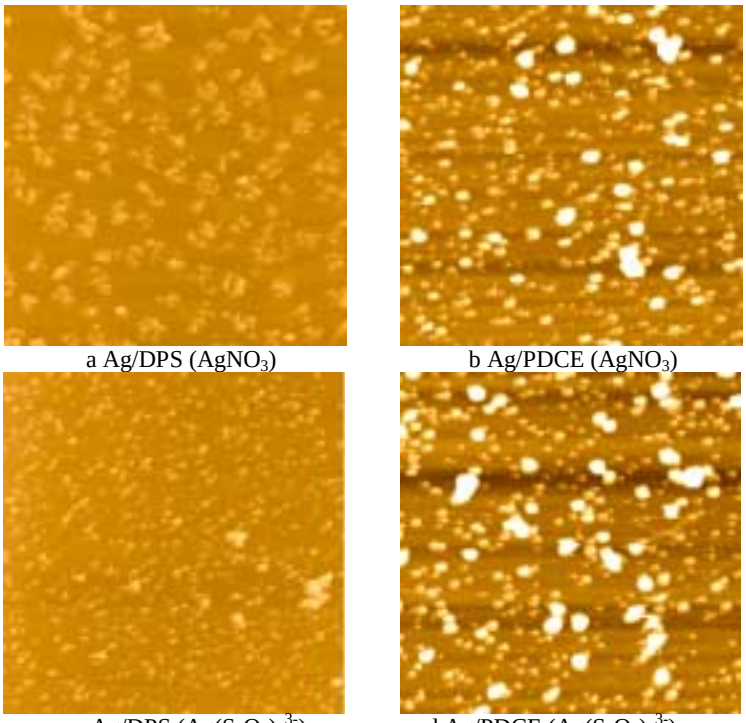
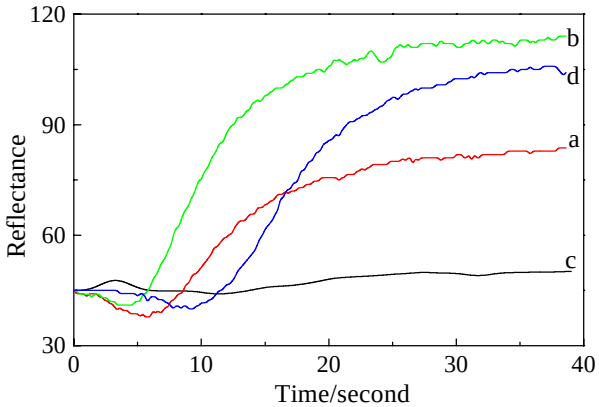


Figure 3 Dynamic curve of physical developing of various silver nanoparticles



a Ag/DPS($AgNO_3$) b Ag/PDCE ($AgNO_3$)
c Ag/DPS($Ag(S_2O_3)_2^{3-}$) d Ag/PDCE ($Ag(S_2O_3)_2^{3-}$)

Compared with UV-vis spectra, AFM observations and catalytic activity curve of Ag nanopartilces, it can be concluded that the role of polymer and surfactant on various Ag ion resources were quite different. Further study is still in process.

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