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Preparation and characterization of CuO/Muscovite flakes pearlescent pigment with UV absorption and high NIR reflectance

Yuksel AKINAY[1], Ihsan Nuri AKKUŞ[1]

Van Yuzuncu Yil University, Engineering Faculty, Mining Engineering, Van/Turkey

Abstracts

The CuO nanoparticles were deposited onto muscovite flakes using sol-gel methods. The thermal, conductivity, optic and structural properties of obtained pigments (CuO/Muscovite) were studied. Hence, the prepared pigments were characterized via using scanning electronic microscopy (SEM) and ultraviolet–visible spectrophotometer (UV-Vis). The results show that CuO was coated on the surface of muscovite flakes uniformly. The obtained pigments show the more stable thermal properties than those obtained from undeposited flakes. The CuO/Muscovite pigments showed high ultraviolet shielding performance. In addition that CuO/Muscovite pigments exhibited higher near-infrared (NIR) reflectance than those of pure-CuO.

Key words: CuO, pearlescent pigment, muscovite, UV absorption, FT-IR

Introduction

Recently, inorganic pigments which are substrate-based and have angle dependent optical effect have call attention owing to their extend implementation on the area of cosmetics, plastics, inks, dyes and optical filters [1-5]. Since increased requirements for angle-dependent pigments for anti-counterfeit and decorative purposes, more researchers were tried to investigate different types of pigments and their production methods [6]. Naturally occurring mica which has high and uniform dielectric constant, good electrical capacitance and known as a one of best thermal insulator is most commercial inorganic substrate which was used to made up pearlescent pigment by deposition of metal oxide layers on the substrate surface due to its structure [7-9]. Moreover, the mica which is a very refractive and reflective surface layer, exhibits a significant pearlescent pigment effect when it is coated with less refractive support material, creating colours owing to from light interference [10-12]. Copper oxides has attracted attention to using in heating or cooling , communications and microwave absorbers systems due to being p-type semiconducting materials that are generally used for sensors, microwave absorption, thermal, optical and catalyst applications [12-15]. Gao and Wu, at all. were explored to effect of phase composition, morphology and particle size on the solar spectral optical properties of mica–titanium pigments by using depositing rutile titanium dioxide onto mica substrates with simple and facile solution methods [13]. Akinay, Y., and Kizilcay, O., have synthesized CuO/Epoxy nanocomposites via using ultrasonic probe sonicator process to investigated microwave absorbing properties of nanocomposites [16].

In this study the CuO deposited on to mica pigments were synthesized by sol-gel method and thermal, optic and dielectric properties of these pigments were investigated for UV shielding and microwave absorbing applications.

Materials and Methods

The CuO and mica flakes with 1:5 mass ratio were mixed in the acetone solution under magnetic stirring at 70 ^{o}C for 24 h. Hence all acetone was removed and then the CuO /mica pigments were calcined at 450 ^{o}C for 4 h. Finally, the prepared pigments were structural characterized via using scanning electronic microscopy (SEM) with energy dispersive x ray spectroscopy (EDX). The thermal and optic properties of pigments were evaluated with Lab SYS EVO DTA/DSC machine and ultraviolet–visible spectrophotometer (UV-Vis).

Results and Discussions

As seen in the Fig.1 which images are taken by using SEM and TEM device, observed the deposition of CuO above the mica flakes. The mica flakes are of 2-3 μm in length such as seen in the TEM image. As stated with red arrows, be an average size of 200-100 nm nano-sized CuO particles were locally piled up to the mica surface.

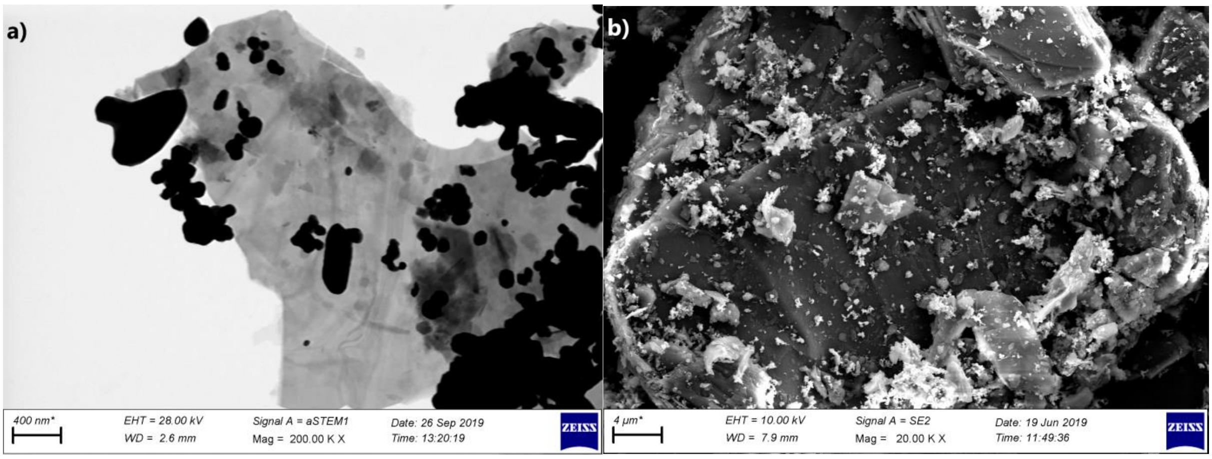
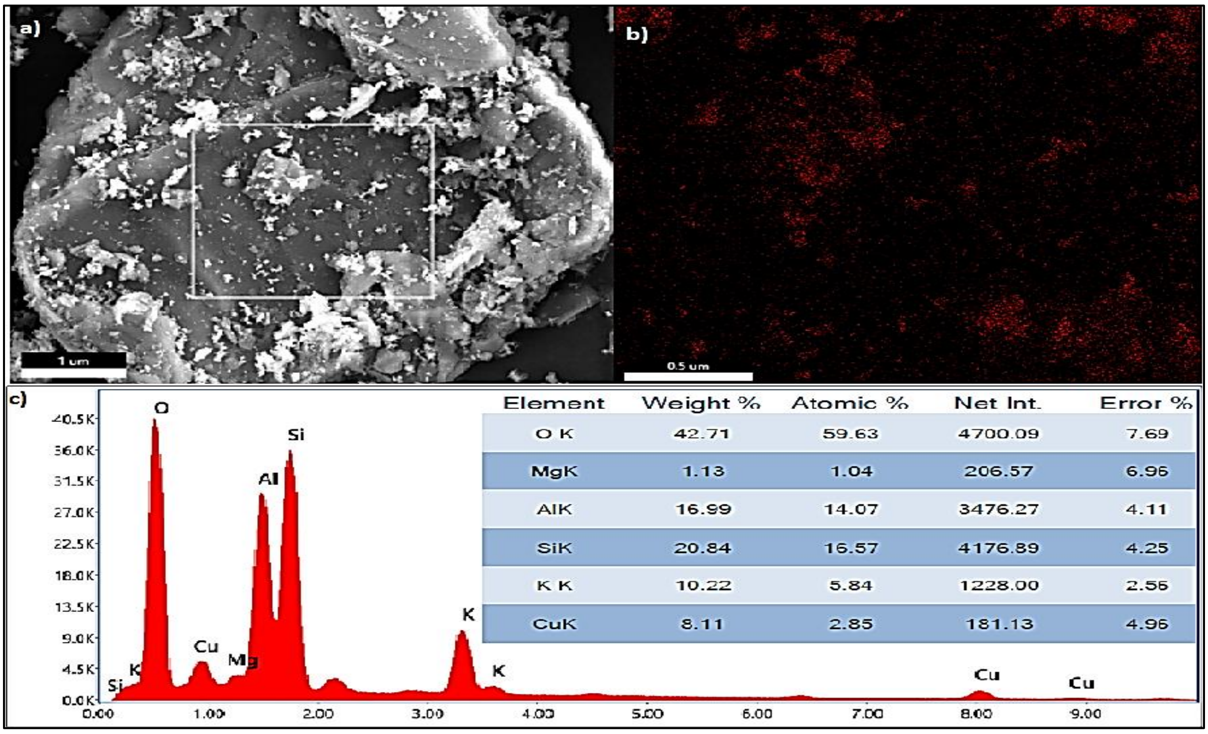


Fig.1. a) TEM image of CuO/Mica, b) SEM image of CuO/Mica

The EDX analysis indicated in Fig. 2 is a good evidence for the presence of CuO on the mica surface. As shown in the Fig.2, the high weight percentages of Cu and O are the evidence of availability of the CuO nanoparticles.



Element	Weight %	Atomic %	Net Int.	Error %
O K	42.71	59.63	4700.09	7.69
MgK	1.13	1.04	206.57	6.96
AlK	16.99	14.07	3476.27	4.11
SiK	20.84	16.57	4176.89	4.25
K K	10.22	5.84	1228.00	2.56
CuK	8.11	2.85	181.13	4.96

Fig.2. a) EDX Selected Area, b) Distribution of Cu on to mica surface, c) Determination of EDX

TGA and UV RESULTS

Fig. 3a. shows the UV-Vis reflectance of particles. It was obviously seen that the mica pigment without any CuO loading shows higher reflectance. When the pigments changed color from white to brown, the reflectance values decreased with CuO loading on the mica particles. Fig 3b shows the thermal weight loss of obtained pigments. It can be seen that the degradation of Mica is larger than that of CuO deposited mica. Hence, the thermal stability of mica has increased with additive of CuO on mica surface.

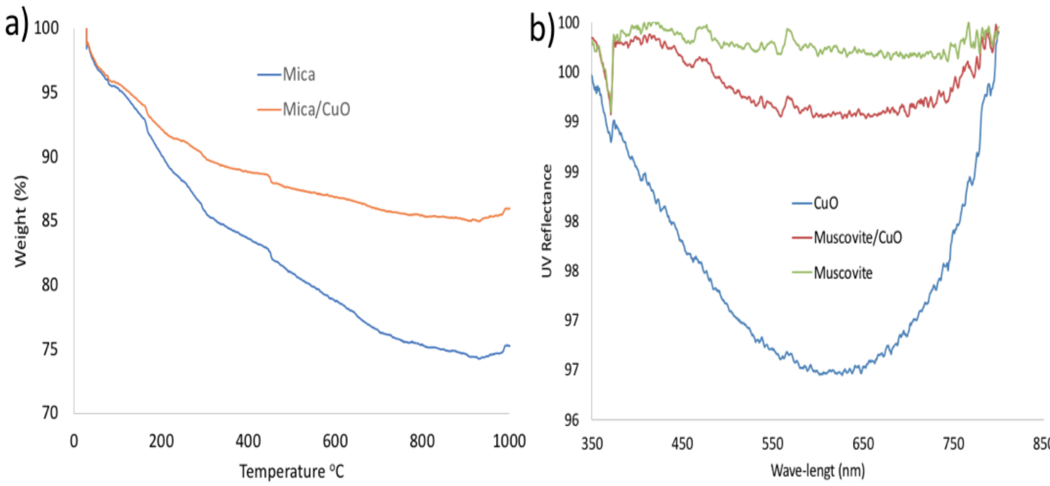


Fig. 3. UV-Vis reflectance spectra curves of the particles

Conclusion

The CuO nanoparticles were deposited on surface of mica flakes by using sol-gel method. The CuO particles are homogeneously dispersed on CuO. The obtained pigments show the more stable thermal properties than undeposited flakes and CuO/Mica pigments showed higher near-infrared (NIR) reflectance than those of pure-CuO.

Reference

1. Y.C. Ryu, T.G. Kim, G. Seo, J.H. Park, C.S. Suh, S. Park, S. Hong, G.D. Lee Effect of substrate on the phase transformation of TiO2 in pearlescent pigment J. Ind. Eng. Chem., 14 (2008), pp. 213-218

2. H. Du, C. Liu, J. Sun, Q. Chen An investigation of angle-dependent optical properties of multi-layer structure pigments formed by metal-oxide-coated mica Powder Technol., 185 (2008), pp. 291-296

3. J.R. Tan, X.S. Fu, W.X. Hou, X.Z. Chen, L. Wang The preparation and characteristics of a multi-cover-layer type, blue mica titania, pearlescent pigment Dyes Pigm., 56 (2003), pp. 93-98

4. M. Mahé, J. Heintz, J. Rödel, P. Reynders Cracking of titania nanocrystalline coatings J. Eur. Ceram. Soc., 28 (2008), pp. 2003-2010

5. Ren, M., Yin, H., Ge, C., Huo, J., Li, X., Wang, A., ... & Wu, Z. (2012). Preparation and characterization of inorganic colored coating layers on lamellar mica-titania substrate. *Applied Surface Science*, *258*(7), 2667-2673.

6. Du, H., Liu, C., Sun, J., & Chen, Q. (2008). An investigation of angle-dependent optical properties of multi-layer structure pigments formed by metal-oxide-coated mica. *Powder Technology*, *185*(3), 291-296.

7. Štengl, V., Šubrt, J., Bakardjieva, S., Kalendova, A., & Kalenda, P. (2003). The preparation and characteristics of pigments based on mica coated with metal oxides. *Dyes and Pigments*, *58*(3), 239-244.

8. Liu, C., Ye, M., Han, A., & Li, J. (2015). Structural analysis and characterization of doped spinel Co2− xMxTiO4 (M= Mg2+, Mn2+, Ni2+, Cu2+ and Zn2+) coated mica composite pigments. *Ceramics International*, *41*(4), 5537-5546.

9. Topuz, B. B., Gündüz, G., Mavis, B., & Çolak, Ü. (2011). The effect of tin dioxide (SnO2) on the anatase-rutile phase transformation of titania (TiO2) in mica-titania pigments and their use in paint. *Dyes and Pigments*, *90*(2), 123-128.

10. Maile, F. J., Pfaff, G., & Reynders, P. (2005). Effect pigments—past, present and future. Progress in organic coatings, 54(3), 150-163.

11. Germer, T. A., & Nadal, M. E. (2001, October). Modeling the appearance of special effect pigment coatings. In *Surface Scattering and Diffraction for Advanced Metrology* (Vol. 4447, pp. 77-86). International Society for Optics and Photonics.

12. Wang, Y., Liu, M., Liu, Y., Luo, J., Lu, X., & Sun, J. (2017). A novel mica-titania@ graphene core-shell structured antistatic composite pearlescent pigment. *Dyes and Pigments*, *136*, 197-204.

13. Gao, Q., Wu, X., & Fan, Y. (2014). Solar spectral optical properties of rutile TiO2 coated mica–titania pigments. Dyes and Pigments, 109, 90-95.

14. Wang, J., Ren, F., Yi, R., Yan, A., Qiu, G., & Liu, X. (2009). Solvothermal synthesis and magnetic properties of size-controlled nickel ferrite nanoparticles. *Journal of Alloys and Compounds*, *479*(1-2), 791-796.

15. Chen, D. H., & He, X. R. (2001). Synthesis of nickel ferrite nanoparticles by sol-gel method. *Materials Research Bulletin*, *36*(7-8), 1369-1377.

16. Akinay, Y., & Kizilcay, A. O. (2019). Computation and modelling of microwave absorbing CuO/graphene nanocomposites. Polymer Composites.