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# The optic and dielectric properties of CuO deposited barite pigments

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## Abstract

The cooper oxide (CuO) deposited barite ($BaSO_4$) pigments (CBP) were obtained by direct deposition method. Optic and dielectric properties of nanocomposites were investigated. Hence, the prepared pigments were structural scanning electron microscope (SEM). The optic properties of pigments were evaluated with ultraviolet–visible spectrophotometer (UV-Vis). The scanning electronic microscopy results show that barite was coated with CuO uniformly. The UV-Vis results show that CuO deposited barite pigments (CBP) have high ultraviolet shielding performance. Furthermore CuO deposited barite pigments (CBP) exhibited UV-Vis reflectance than those of pure-CuO. Furthermore, the conductivity of barite flakes increased with the coating of CuO nanoparticles. The dielectric properties of CuO deposited barite pigments were determined in the frequency range of 8.2–12.4 GHz via vector network analyzer and the electromagnetic absorption properties of nanocomposite was determined and calculated by using these dielectric values (permittivity). CuO deposited barite/epoxy nanocomposite (mass ratio is 3:10) with 2 mm thickness showed a minimum reflection loss of -9 dB at 12.25 GHz frequency. Furthermore, the conductivity of barite flakes increased with the coating of CuO nanoparticles.

**Key words:** UV-Vis reflectance, CuO, pearlescent pigment, barite dielectric properties

## 1. Introduction

Recently, the rapid development of energy, defense, communication and other industries have forced to investigate new functional materials. The increase of electromagnetic pollution has become serious problem for environment, telecommunication devices and stealth technology [1-3]. However, the nuclear energy applications, oil transportation lead to environmental pollution. Herein, CuO has attracted more attention for communication, microwave absorbers, heating or cooling systems [4].

Copper oxides are p-type semiconducting material that using for sensors, catalysts, microwave absorption, thermal and optical applications [5,6]. Moreover, CuO can be used for dual coating process due to interacting with other oxides. Wan, Y., et al. have dual coated CuO and FeCo deposited carbon fibers with facile electrodeposition and oxidization methods [7]. Jun and Xu, has synthesized CuO/Co/Carbon fiber by using twice electroless plating for microwave absorption application [8] In addition that Barite (BaSO4) is a most important candidate for the oil and gas industry [9]. Barite is generally used as a radio contrast due to its well X-Ray absorbing properties and also it has a good radiation shielding performance [10-13].

In this paper the CuO deposited Barite pigments were synthesized by direct deposition method and thermal, optic and dielectric properties of these pigments were investigated for UV shielding and microwave absorbing applications.

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## 2. Materials and Method

The CuO with 100-150 nm were deposited on Barite flakes via direct deposition method and the composition of CuO in with 1:5 mass ratio were mixed in the solution under magnetic stirring at 70 $^{o}$C for 24 h then the CuO/Barite 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) (10 kV with Secondary electron (SE) detector), and Fourier transform infrared (FT-IR) methods. The optic properties of pigments were evaluated with ultraviolet–visible spectrophotometer (UV-Vis). The dielectric properties of prepared nanocomposites were determined in the frequency range of 8.2–12.4 GHz via vector network analyzer and the microwave absorption properties of these nanocomposites were calculated by using these dielectric values (permittivity).

## 3. Results

Fig. 1 shows the SEM, TEM and EDX results of CuO deposited barite flakes. As seen in the TEM image, the barite flakes are of 2-3 μm in length. As indicated with red arrows, the CuO nanoparticles were locally deposited on barite surface with an average size of 200-100 nm. The existence of CuO on barite surface has also proven with EDX analysis. The high Cu and O rate is the evidence of CuO nanoparticles.

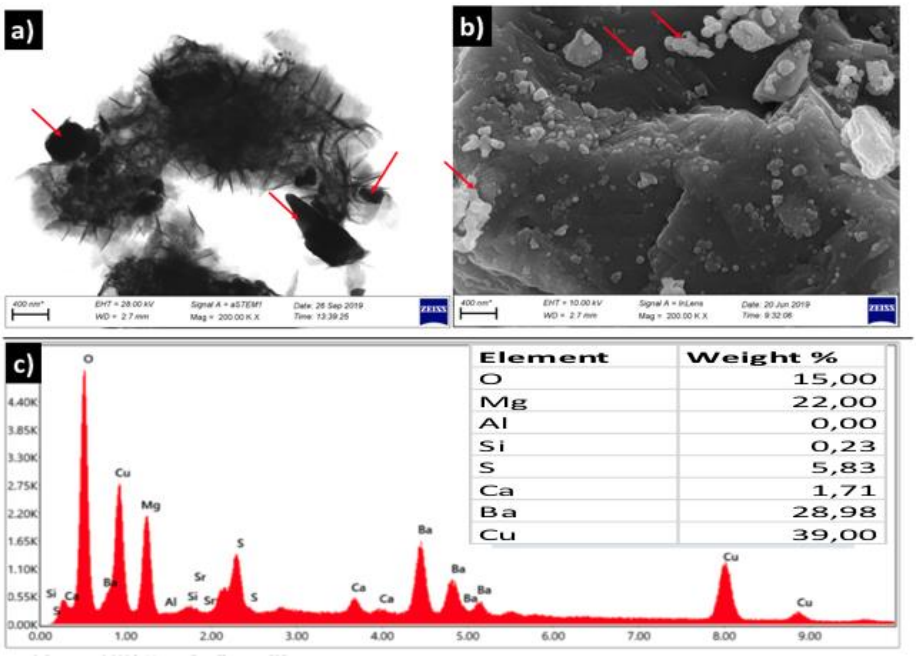


Fig. 1. a) TEM image of CuO/Barite, b) SEM image of CuO/Barite, c) EDX analyses of CuO/Barite

Fig. 2. shows the UV-Vis reflectance of particles. It was obviously seen that the reflectance of barite is higher than 0.9 due to its white color. When the pigments changed color from white to

gray, the reflectance values decreased with CuO loading on the mica particles. This is can be explained with Kubelka-Munk (KM) theory [14].

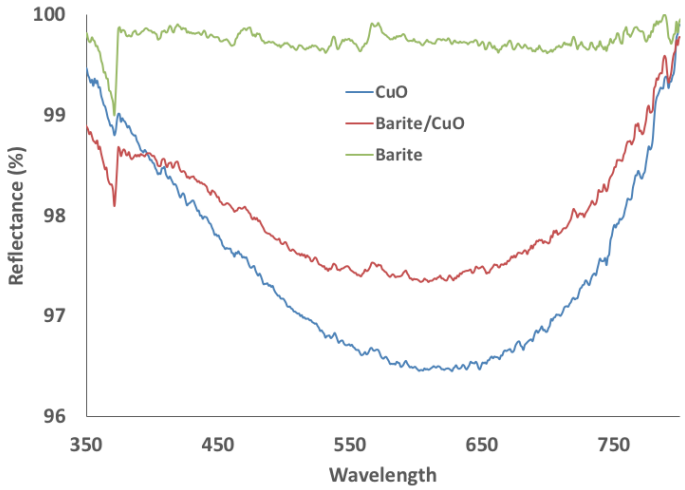


Fig. 2. UV-Vis reflectance spectra curves of the particles

The electrical conductivity versus frequency of obtained pigments is given in Fig. 3. As expected, CuO has increased the conductivity of Barite. Hence, CuO deposited barite pigments act as semi conductive particles. The microwave absorbing properties of CuO deposited barite pigments were calculated with dielectric properties for the thickness of 2.5 mm.

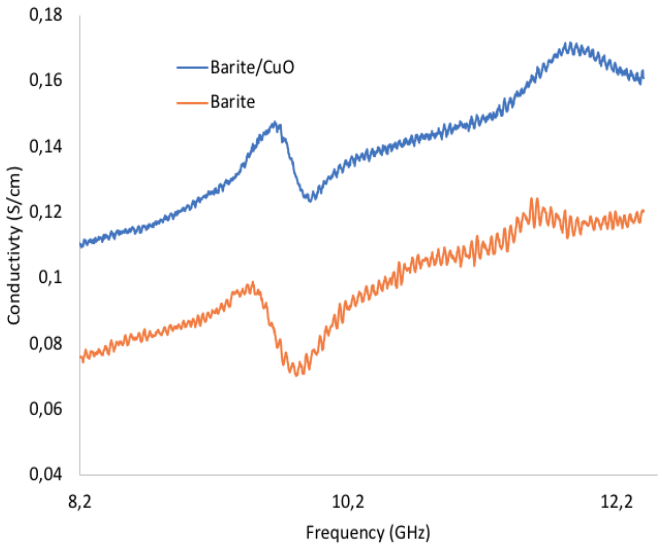


Fig. 3. The electrical conductivity of obtained pigments

The Reflection Loss ($R_L$) results of CuO/Barite pigment for 2.5 mm thickness is given in Fig. 4. The attenuate of the incident wave through the materials is evaluated by three reason. Reflection,

microwave absorption throughout the material's thickness and multiple reflections are the three mechanisms for electromagnetic attenuation [15-17].

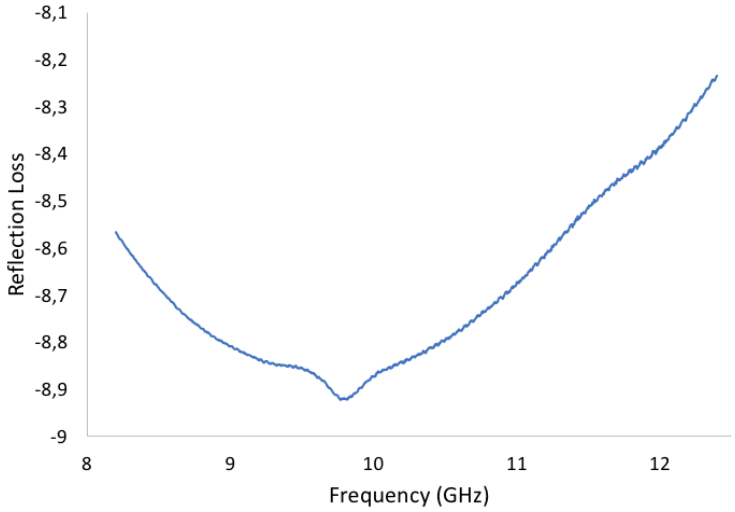


Fig. 4. The Reflection Loss ($R_L$) results of CuO/Barite pigment for 2.5 mm thickness

The uniform microwave heating can be obtained with decrease of particle size and this mechanism provides better microwave absorption [18]. The microwave heating within homogeneous and heterogeneous materials is described by two parameters: The complex permittivity ( $\varepsilon^* = \varepsilon' - j\varepsilon''$ ) and complex permeability ($\mu^* = \mu' - j\mu''$) [19,20]. The $R_L$ values are less than – 8 dB at X-band and the minimum $R_L$ is found -8,92 dB at 9.8 GHz.

## Conclusions

The CuO/Barite pigment were synthesized using sol-gel methods and the structural , dielectric and optical properties were evaluated. The results show that the CuO naparticles were well deposited on the mica flakes. The $R_L$ value of CuO/mika pigments filled epoxy composite are less than – 8 dB at X-band and the minimum $R_L$ is found -8,92 dB at 9.8 GHz.

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