Applied Clay Science 107 (2015) 205–212

Contents lists available at ScienceDirect

Applied Clay Science

journal homepage: www.elsevier.com/locate/clay

Research paper

Development of transition metal oxide–kaolin composite pigments for potential application in paint systems

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ARTICLE INFO

Article history:
Received 26 September 2014
Received in revised form 7 January 2015
Accepted 30 January 2015
Available online 12 February 2015

Keywords:
Kaolin
Metal oxide composite
Ceramic pigment
Antimicrobial potency
PEG analysis

ABSTRACT

The present work deals with a simplified process for synthesizing metal oxides of Cu(II), Ni(II), Cr(III) and Fe(III) imbibed kaolin pigments and characterizing those samples using X-ray diffraction, Fourier transform infrared spectroscopy, FESEM and EDS in addition to the visual classification by color. Furthermore, PEG analysis and antimicrobial potency of these samples were investigated thoroughly which conferred positive impact depicting the fact that these metal oxides incorporated kaolin composites can serve as a good and promising ceramic pigment material in paint systems. Due to easy availability of kaolin and involvement of low temperature, the production cost of these synthesized pigments is highly reduced which can be an added advantage to the paint industry.

1. Introduction

The recent era has witnessed the blooming rise in the development of tailored materials with multifunctional properties. It is well known that the transitional metallic oxides are chromophores and hence are a source of pigments (Pishch et al., 2011). The transitional metals like Cu, Ni, Cr and Fe have unfilled electronic shells and possess high polarizability. Generally the formation of the complex ions of these metals due to the incorporation of oxygen, shifts the absorption band in the visible region of the electromagnetic spectrum and is accountable for obtaining a wide range of colored pigments. However some of these materials also possess antimicrobial properties which when incorporated into the paint systems act as agents to control the growth of microbes. It is a matter of concern that majority of the harmful microorganisms have developed a gradual resistance to most of the conventional antimicrobial agents. This has led researchers towards engineered nanomaterials as a way out to the problem. Recent studies have been reported about the antimicrobial effects of various materials (Moralesa et al., 2003). The development of various new microbe deterrents is an ever evolving expertise. In this context the oxides of metals like copper, nickel, iron, chromium, etc. in their nano or micro regime prove to be ideal antimicrobials (Pang et al., 2009; El-Nahhal et al., 2013; Hans et al., 2013; Prodan et al., 2013; Swain et al., 2014).

Paints have been manufactured since time immemorial but until recently they were highly expensive. Hence, a promising direction in research is to study the plausibility of synthesizing ceramic pigments using natural mineral raw material which could make the pigments cost-effective and available in all sectors. Inorganic pigments using metal oxides in ceramic and plastic industry have attracted attention at the present time. In general, inorganic pigments are superior to organic ones in heat and light permanency, weather resistance and low cost. Few works related to ceramic pigments using silica gel as the precursor have been reported earlier (Krysztafkiewicz et al., 2003; Pishch et al., 2011). The pigments based on the silica are popular among ceramic pigments. Besides silicates, aluminosilicates can also be used as another silica source. Kaolin, an aluminosilicate material can be used as the silica source to synthesize ceramic pigments.

Kaolin is a natural light colored clay occurring worldwide in large deposits and hence is an inexpensive raw material. It has good dispersibility in water based system, good opacity, gloss and brush ability. It is used as a precursor in paper industry. Pigments based on kaolin can be used in colored paper production, as colored pigment or extender in paint industry. In decorative paints it will be a good ingredient. Kaolin, with the chemical composition $Al_2Si_2O_5(OH)_4$ is available in pure form and in very fine particles. It is a layered silicate with one tetrahedral sheet linked through oxygen atoms to one octahedral sheet of alumina. It has a special water retentive property. These particles slide over each other to form plastic clay like mass. Other special features include its good thermal resistivity, good electrical insulation and non-abrasiveness. It is used in paint as it is chemically inert over a wide pH range, has a high covering power, is a good plasticizer, provides smoother surfaces, and gives more attractive finish and good dimensional stability. In addition, kaolin is also a versatile extender

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http://dx.doi.org/10.1016/j.clay.2015.01.029
0169-1317/

Table 1
Kaolin–metal oxide composites and their respective colors.

Kaolin–metal oxide composites	Color
Kaolin–CuO	Black
Kaolin–NiO	Gray
Kaolin–Cr_2O_3	Green
Kaolin–Fe_2O_3	Red

pigment which apart from giving good performance in paint films, also gives ample opportunity for value addition by physical, structural and chemical modification with enhanced performance (Slepetys and Cleland, 1993; El-Sabbagh et al., 2012).

The present work focuses on the low temperature preparation of kaolin–metal oxide ceramic pigment from oxides of Cu(II), Ni(II), Cr(III) and Fe(III) [K–CuO, K–NiO, K–Cr_2O_3, K–Fe_2O_3 samples respectively] in a cost-effective way. The synthesized composite samples of metal oxide embedded in kaolin matrix serve a two-fold purpose as a pigment and

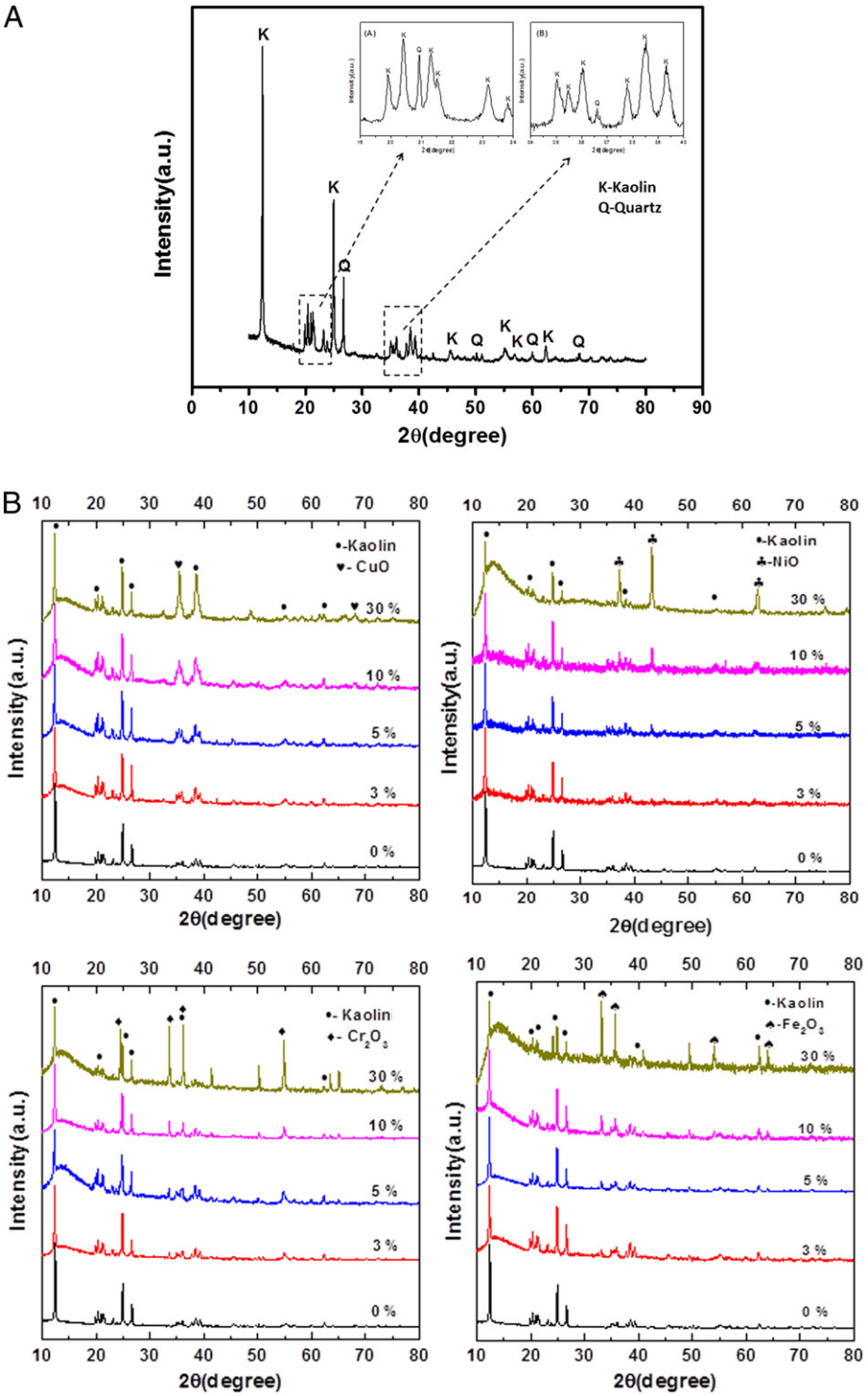

Fig. 1. (a): XRD pattern of purified kaolin powder sample. (b): XRD patterns of kaolin–metal oxide composite samples with various mass ratios of oxides from 0 to 30%.