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ORIGINAL PAPER

Pigmentary properties of rutile TiO_2 modified with cerium, phosphorus, potassium, and aluminium

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The influence of different modifiers, phosphorus, potassium, aluminium, and cerium on the pigmentary properties of TiO_2 was studied. The phase composition and distribution of modifiers in prepared TiO_2 products was investigated using XRD analysis, the selective leaching method, and ICP–AES technique. The optical properties, photoactivity, morphology, and surface area of modified TiO_2 were determined by spectrophotometric, fluorescent, SEM, and BET measurements. The research was directed towards obtaining a pigmentary TiO_2 with the highest possible photostability. It was found that the final calcination temperature, at which the anatase–rutile transformation rate was > 97 %, depended on the kind and amount of the modifiers introduced into hydrated titanium dioxide. In comparing the colour of TiO_2 products modified with Ce, it was found that the addition of K to the TiO_2 series caused an increase in all the optical properties examined. The presence of K and Al in TiO_2 modified with Ce resulted in decreased photocatalytic activity. The photostability of TiO_2 modified with Ce and K improved with an increase in P_2O_5 content. The highest photostability was measured for the TiO_2–CePKAl series. It was concluded that the differences in both the optical properties and photoactivity of TiO_2 depended on its phase composition and the distribution of modifiers in the products obtained.

Keywords: titanium dioxide, modification, photostability, optical properties, pigmentary properties

Introduction

In nature, titanium dioxide crystallises in three forms of brookite, anatase, and rutile (Diebold, 2003). Brookite is difficult to obtain, hence has no value in the TiO_2 industry (Bellussi et al., 2002). Anatase is a superior photocatalytic material for air and water purification, water disinfection, and hazardous waste remediation; it is applied to thin films and batteries (Fu et al., 2006; Li et al., 2011). Rutile is the most widely used white pigment nowadays (Woditsch & Westerhaus, 1993; Tayade et al., 2007). Inorganic TiO_2 pigments have applications in a variety of products including paints, inks, plastics, paper, rubber, ceramics, enamels, textiles, food, glasses, and pharmaceuticals (Lewis, 1988; Rao & Reddy, 2007). It is worth noting that the increase in demand for TiO_2 pigments in Europe is estimated at 3 % per year, while in Asia double-digit rates are projected. Global TiO_2 pigment consumption increased by 9 % in 2010 (Elsevier, 2011).

The more compact structure of rutile in comparison with anatase affords the differences between these two forms. Rutile is the most thermodynamically stable form of the TiO_2 polymorphs. In addition, rutile possesses greater brightness, hiding power, tinting strength, whitening ability, and opacity (Dąbrowski et al., 2006; Reidy et al., 2006). As a consequence, this form of titanium dioxide is preferred in the pigment industry for its outstanding optical properties. The colour of TiO_2 is decisive for its optical performance since the titanium dioxide pigment is used in a wide

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