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Understanding of naphthalene sulfonate formaldehyde condensates as a dispersing agent to stabilise raw porcelain gres suspensions Surface adsorption and rheological behaviour

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Abstract

The continuous demand of porcelain gres as a raw material for many ceramic applications is requiring a particular attention to the green body properties. The fluidity of these suspensions must be appropriate and their solid content must be as high as possible in order to minimize the drying cost. In this work, slightly additions of sodium acrylate copolymer and naphthalene sulfonate formaldehyde condensate (SNSFC) in the classical deflocculating mixture with sodium silicate were tested. The stability of dispersions was investigated through adsorption isotherms and rheological properties. The results show that the naphthalene sulfonate formaldehyde condensates proved to be effective as dispersant for raw porcelain suspensions.

Keywords: Porcelain; Suspension; Powders—chemical preparation; Silicates; Toughness and toughening

1. Introduction

Within the great range of products offered by the ceramic industry, developments in porcelain tile, commonly referred to as porcelain gres, have been outstanding. It is thought that from 1996 to 2000, the production has increased currently accounting for 40% of European's total product output. And manufacturers in Latin America, the Far East and even the United States are standing to gear up for production of this increasingly popular material. As the demand for porcelain gres continues to increase, leading edge techniques will be required to assist manufacturers in improving their products. Some processing techniques, for example slip casting or injection moulding, use ceramic suspension with high solid volume [1] and proper stability to improve its economics. However, with increasing solid loading, processing of a suspension becomes increasingly difficult. Since its flow characteristics are usually of crucial importance, they have to be controlled in order to yield a final product with the best properties as well as to improve the economics of the process to optimize energy requirements [2]. In general, a controlling viscosity and an adequate stability of concentrated suspension is an essential part of successful porcelain powder processing. This stability is produced by the interaction of moving porcelain particles within the interparticle fluid [3]. In general, it is strongly affected not only by solid loading, but also by chemical aspects, i.e. of pH and/or addition of dispersing agents.

It is well known that dispersing agents based on polyelectrolytes, such as polyacrylates, polysaccharides and polystyrene sulfonates, have been used in the preparation of these concentrated suspensions [4]. The purpose of this paper is to investigate the stability of concentrated suspensions of raw porcelain particles in the presence of different anionic polyelectrolytes, in the classical and economical deflocculating mixture with sodium silicate [5,6], in order to find the more effective dispersing agents for maximizing the solid loading of the suspension. From the experimental results, it is possible to qualitatively analyze the relationship between polymer adsorption onto the particle, rheological characterization and the stability of concentrated suspensions. In this context the adsorption of different additives on porcelain gres has been investigated in order to relate the adsorption density of polymer onto the surface of porcelain gres and the electrostatic and steric forces [7]. Moreover, rheological

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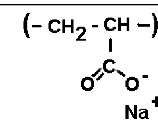
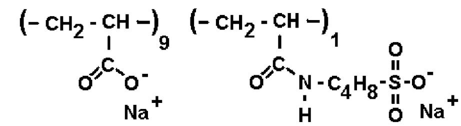
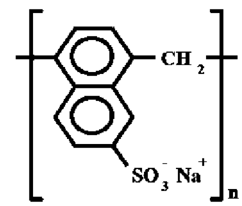
Table 1
Chemical structure and some characteristics of the tested polyelectrolytes

Polymer	Chemical structure
Sodium acrylate homopolymer (SA). MW = 2000 Da; max. polymer charge density (pH ∼ 8) = 1270 C/g	
Copolymer of sodium acrylate (SA) and sodium alkyl sulfonated (SS). MW = 4000 Da; max. polymer charge density (pH ∼ 8) = 1075 C/g	
Sodium salt of copolymer of formaldehyde β-naphthalene sulfonate (SNSFC). MW = 2000 Da Na sulfate content (%) = 1; max. polymer charge density (pH ∼ 8) = 395 C/g	

measurements have been used for the study and evaluation of powder suspensions [8].

2. Experimental procedure

2.1. Materials

The basic composition of the raw porcelain gres material was a synthetic mixture supplied by ECESA (Lugo, Spain) whose mineralogical composition was 45% feldspar, 15% plastic clay and 40% kaolinite. The average particle diameter was 2.1 μm, determined by laser diffraction (LD). The specific surface area for this powder was found to be 13.4 $m^2 g^{-1}$, determined by nitrogen adsorption (BET). The isoelectric point (IEP) was found to be at pH 9, determined by the acid–base titration method [9]. Three types of polymers have been evaluated: (1) a linear homopolymer of sodium acrylate (SA), with the hydrophilic weak acid carboxylate group, (2) a copolymer of sodium acrylate (SA) and sodium alkyl sulfonated (SS) with the hydrophilic strong acid sulfonic group and, (3) a condensate of sodium naphthalene sulfonate formaldehyde (SNSFC) with the hydrophilic strong acid sulfonic group and the hydrophobic aromatic backbone. Some physical properties and the chemical structures of these dispersants are given in Table 1. The two polymers based on sodium acrylate, SA and SA/SS, have been supplied by Rohm and Haas Company, whereas the SNSFC polymer (Tamol NN 4501) has been provided by BASF Corporation. The infrared spectrum of the used SNSFC is presented in Fig. 1. The infrared spectrum contains the aromatic C–H stretch band at 3070 cm^{-1}, the aromatic ring modes at 1640, 1596 and 1507 cm^{-1} and the sulfonate group bands at 1190, and 1033 cm^{-1}. Additionally, the spectrum contains the methylene C–H bending (scissors) vibration at 1450 cm^{-1}.

All tested deflocculant mixtures have been composed by a 25% of polymer (50% of solid content) and a 75% of sodium silicate ($SiO_2/Na_2O = 1$) supplied by FMC Foret Corporation.

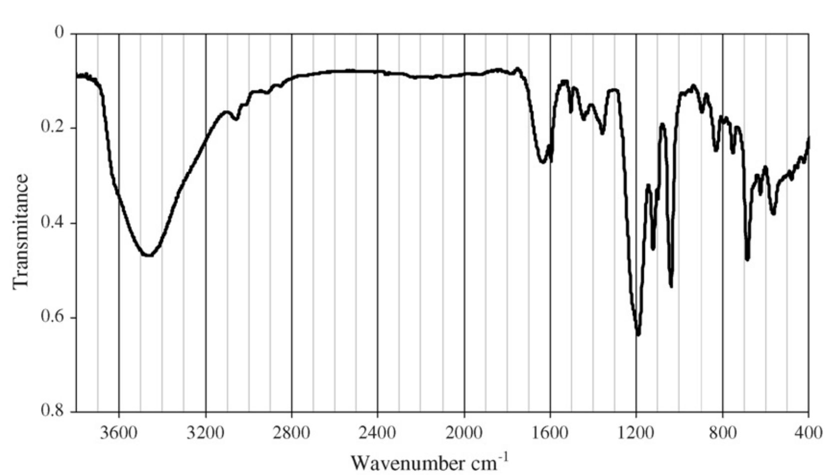


Fig. 1. Infrared spectrum of the used SNSFC.