INFLUENCE OF DIFFERENT TYPES OF SODIUM SILICATE IN COMPOSITIONS OF TRIAXIAL CERAMICS USING A MIXTURE DESIGN APPROACH

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ABSTRACT

The aim of this work is to study the influence of two different types of sodium silicate on the rheological behaviour of triaxial ceramic suspensions. Slurries with 40 wt% solids content were prepared for each composition and the minimum amount of deflocculant was determined. It was observed that an increase in the alkalinity of the sodium silicate resulted in lower apparent viscosity values of the dispersions. Response surfaces and polynomial regressions were used to identify the optimum amount of deflocculant.

Key words: *Wet processing, sodium silicate and mixture design.*

1. INTRODUCTION

Sodium silicate is widely used in the ceramic industry due to its low cost and high deflocculant effect (Ortega, 1997). Commercially, it has the general molecular formula (Falcone Jr., 1997):

$Na_2O.mSiO_2$.

where, m, the modulus, and n are the number of moles of SiO_2 and H_2O, respectively, per mole of Na_2O.

Its main deflocculation mechanism is based on an electrostatic effect. When sodium silicate is added to ceramic suspensions, viscosity decreases due to the formation of face-to-face contacts (Yildiz et al., 1998); in addition, the hysteresis loop area decreases (Garrido et al., 1988).

2. MATERIALS AND METHODS

Suspensions with 40 wt% solids were prepared using a planetary ball mill with alumina grinding media until reaching less than 0.6 wt% of residue on a 325-mesh (44 μm) sieve. Dehydrated sodium silicate powders (Manchester, SiO_2:Na_2O weight ratios equal to 1:3 and 3:3) were used as deflocculants, calculated on a solid dry weight basis and added before the ball milling, similarly to the procedure commonly used in the ceramic industry (Raupp Pereira, 2002). Apparent viscosity measurements were carried out with a rotational viscometer (Rheotest 2.1, MLW) using coaxial cylinder geometry.

To apply the mixture design, it was necessary to find, for each composition, a value of deflocculant content that provided the suspensions with minimum apparent viscosity. This optimum deflocculant amount (ODA) was found as the experimental point corresponding to the lowest value of apparent viscosity considering the two nearest experimental points.

3. RESULTS AND DISCUSSION

Table 1 presents the optimum deflocculant amount observed in two types of sodium silicate.

COMPOSITIONS		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
ODA (%)	Ratio 1:3	0.7	0.02	0.05	0.2	0.05	0.07	0.3	0.1	0.02	0.05
	Ratio 3.3	0.7	0.1	0.08	0.6	0.5	0.2	0.7	0.3	0.1	0.06

Table 1. Optimum deflocculant amount (ODA) obtained for sodium silicates with different SiO_2:Na_2O ratios.

As can be observed in Table 1, on increasing the alkalinity of sodium silicate, smaller amounts of deflocculant are required to reach low values of apparent viscosity. According to Reed (1995), higher SiO_2:Na_2O ratios imply longer SiO_2 chains, and consequently, lower values of alkalinity, mainly because Na^+ ions are distributed non-uniformly in the interstices of the disordered silica network (Falcone Jr., 1997).

Figures 1 (a) and (b) present the equations of the quantitative influence of the weight fractions of the pseudo-components – clay mineral (X_C*), feldspar (X_F*) and quartz (X_Q*) – on the optimum deflocculant amount (ODA), as well as the response surface presented by sodium silicate with Na_2O:SiO_2 ratios equal to 1:3 and 3:3, respectively, modelled by quadratic regression.

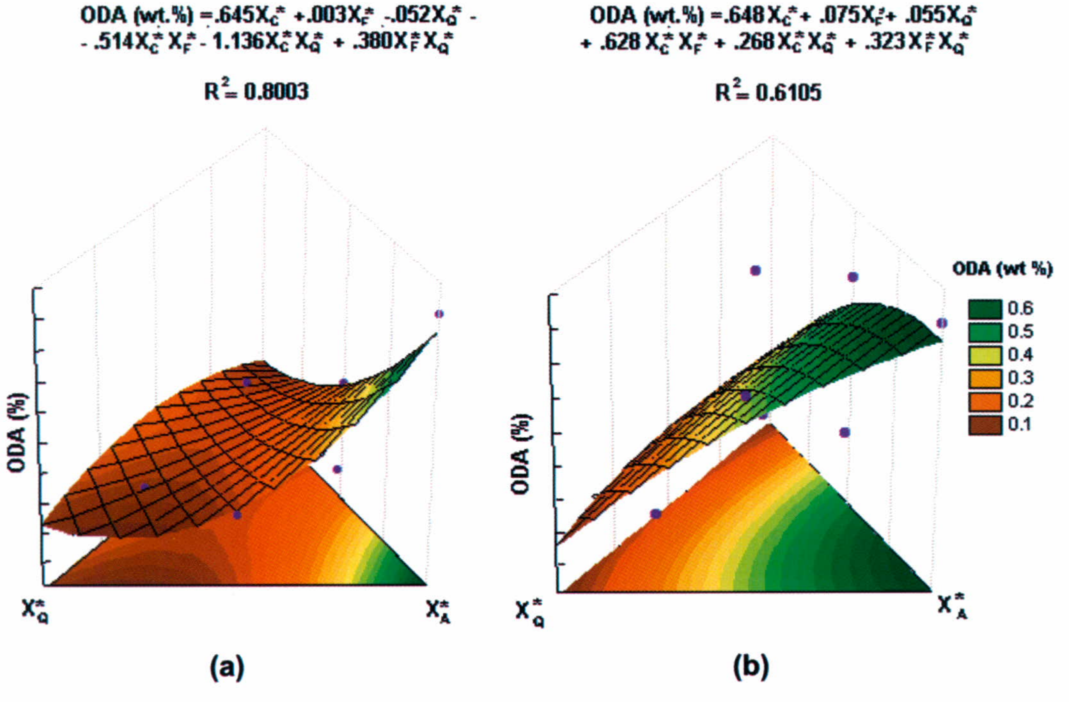

Figure 1. Quantitative influence and response surface presented by compositions with sodium silicate (a) 1.3 SiO_2:Na_2O ratio and (b) 3.3 SiO_2:Na_2O ratio.

As Figure 1 shows, compositions with high clay mineral contents required higher amounts of deflocculant. According to Yidiz et al. (1998), the electrolyte ions are mainly adsorbed onto the fracture kaolinite crystals, having unsaturated areas due to broken valence bonds. The sodium silicate deflocculation mechanism is based on the neutralization of the negative clay mineral particle surface by Na^+ ions, reducing the interparticle forces. Furthermore, the silicate ions can combine with positive flocculating cations, such as Mg^{2+}, Ca^{2+} and Al^{3+}, present in the solution. When these multivalent flocculating cations combine with a silicate anion, they precipitate in the form of insoluble silicates (Dinger, 2002).

4. CONCLUSION

Increasing the alkalinity of sodium silicate, smaller amounts of deflocculant are required to reach lower values of apparent viscosity. Sodium silicate also enhances the negative particle surface charges in suspensions by removing flocculating cations.

5. ACKNOWLEDGEMENTS

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