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ELECTROKINETIC POTENTIAL AND STABILITY OF  
SiC SUSPENSIONS IN ELECTROLYTE SOLUTIONS

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| 16. Abstract<br><br>The dependence of zeta potential on pH of an aq. Si carbide suspension was studied by an electroosmosis method. The effect of pH on the Si carbide elec double layer is attributed to the participation of H and OH ions in the surface dissochn. reactions of weak acid OH groups on an oxidized carbide surface. Max stability of the suspensions was obsd. at max. neg. zeta potentials.<br><br><p style="text-align: center;">ORIGINAL SOURCE<br/>OF POOR QUALITY</p> |  |   |  |
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ELECTROKINETIC POTENTIAL AND STABILITY OF SiC SUSPENSIONS  
IN ELECTROLYTE SOLUTIONS

/53\*

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Summary

Zeta potential of SiC in solutions of HCl, NaOH,  $\text{Na}_2\text{SiO}_3$  and  $\text{Na}_2\text{CO}_3$  determined by the electro-osmosis method is compared with the stability of suspensions of SiC. Results are discussed from the point of view of taking part of the  $\text{H}^+$  and  $\text{OH}^-$  ions in dissociation reactions of the surface of weak acid OH groups.

The inability to use slip casting as a method of forming products made of refractory compounds of the carbide, boride, nitride and silicide types is primarily associated with the difficulties arising in the preparation of stable suspensions of these compounds [3]. Up to now the causes conditioning the stability of these suspensions remain unknown.

Deryagin's physical theory of stability [2] is constructed on investigations of the balance between the forces of attraction and repulsion of separate particles in the dispersion phase of the system. According to this theory, the forces of repulsion are of an electrical nature, and in a first approximation they can be evaluated according to their electrokinetic potential.

This report presents the results found in research on the effect of the electrolytes of HCl, NaOH,  $\text{Na}_2\text{SiO}_3$  and  $\text{Na}_2\text{CO}_3$  on the zeta potential and the stability of suspensions of silicon carbide, which are used more and more commonly in technology [5].

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We studied the silicon carbide both in the industrial form and as admixtures treated with hydrochloric acid and washed until the rinsed liquid had a stable electrical conductivity. We measured the zeta potential with the electroosmosis method [4]. We evaluated the stability of the suspensions according to the optical density of the centrifuged suspension. The research results can be seen in Figures 1-3.

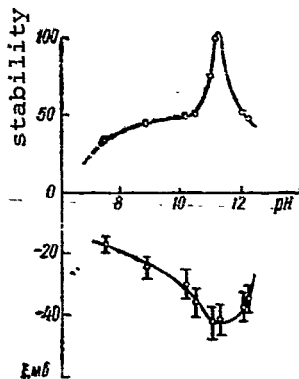


Figure 1. Dependence of the zeta potential and stability of a suspension of technical silicon carbide on the pH.

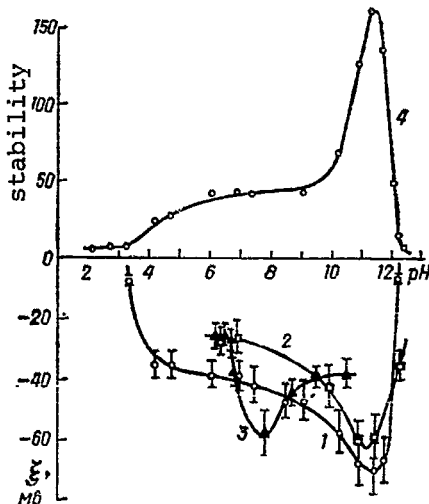


Figure 2. Dependence of the zeta potential and stability of a suspension of refined silicon carbide on the pH with additives of HCl, NaOH (1, 4), Na<sub>2</sub>CO<sub>3</sub> (2) and Na<sub>2</sub>CO<sub>3</sub> (3).

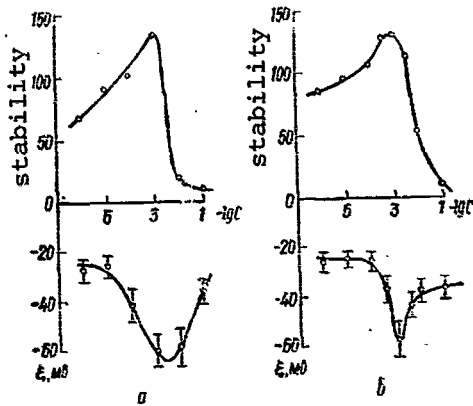


Figure 3. The dependence of the zeta potential and stability of a suspension of refined silicon carbide on the concentrations of sodium silicates (a) and sodium carbonates (b).

Suspensions of silicon carbide in distilled water are characterized by small quantities of negative zeta potential. The zeta potential of refined material (-39mw) is higher in absolute value than that of the technical product (-18mw). This is certainly associated with the presence in the industrial product of admixtures of iron, which were revealed by chemical analysis methods. Iron oxides in water have a positive surface charge [8], and their presence masks the negative charge of the surface of the silicon carbide [6]. With the addition of alkali, the most negative zeta potentials are observed at  $pH \approx 11.2$  for technical and  $pH \approx 11.4$  for refined specimens. A further increase in the alkali concentration in the supply system sharply reduces the zeta potential of the carbide.

The addition of hydrochloric acid to the suspension reduces the negative zeta potential. The existence of an iron admixture in the technical product greatly affects the results of measurements of the zeta potential in the acidic environment. This effect is based on the contact time between the suspension and the acid solution. If the contact time is short (up to five minutes), the pH ratio of the zeta

potential is almost the same as for pure carbide, while increasing the time shifts the curve  $\zeta = f(\text{pH})$  for the technical product to a higher alkali zone. This shift embraces almost 4 pH units with contact longer than 24 hours. These results are not shown in Figure 1, since those measurements were intended only for orientation. The zeta potential dependence on the pH renders it possible to determine the isoelectrical point, which is  $\text{pH} \approx 3.2$  for refined silicon carbide. /54

In adding sodium carbonates and silicates to a suspension of refined silicon carbide, the negative zeta potential (Figure 3) increases and reaches the highest values in an electrolyte concentration of  $5 \cdot 10^{-3} \text{ n}$ . The effect of these electrolytes on the electrical double layer of carbide may be produced by the following causes. First of all, the growth in the zeta potential with an increase in the concentration of these salts can be connected with an increase in the electrothermodynamic potential of the silicon carbide surface in the calculation of the possible (by the Panet-Fayance rule) potential occasioned by the adsorption of ions of silicate and carbonate. Secondly, the hydrolysis of these salts in an aqueous solution cannot help raising the alkalinity of the medium, which, as the data from Figure 2 confirm, leads to an increase in the negative zeta potential. As can be seen from Figure 2, the dependence of the zeta potential on the pH in the presence of sodium silicate is almost the same as in the presence of caustic soda. The maximum zeta potential is found at  $\text{pH} \approx 11.3$ . For sodium carbonate, the maximum zeta potential is observed at  $\text{pH} \approx 7.8$ , at which an NaOH solution still does not provoke noticeable changes in the zeta potential.

In this way it is possible to assume that the action of the sodium silicate is conditioned only by hydrolysis; for the carbonate a potential conditioned by anion adsorption prevails.

In general the stability of sodium carbide suspensions is not high. In all solutions the maximal stability correlates with the greatest negative zeta potential values. This /55 justifies the observation that, just as for titanium carbide [4], the major role in the mechanism of stabilizing the silicon carbide suspension in aqueous solutions is played by the electrical factor.

In this way it is possible to draw a conclusion regarding the surface effect of the  $\text{OH}^-$  and  $\text{H}^+$  ions on the double electrical layer of the silicon carbide surface in aqueous solutions. In analogy with some other carbides [1], it can be observed that the silicon carbide surface is coated with a film of oxide, which our data can explain from the standpoint of the pH effect on the acidic dissociation of these molecular groups, raising the negative charge on the surface, revealed in the increase in the negative values of the zeta potential. Acidification of the solution retards the dissociation of the OH groups, reducing the negative charge and the zeta potential of the surface.

Such an explanation is also credible because of the fact that the isoelectrical point of the silicon carbide (pH = 3.2) correlates quite well with the zero charge (pH = 3.6) and the isoelectrical point (pH = 3.7) [7] of roughly and highly dispersed quartz.

## References

1. Avgustinnik, A.I., Drozdetskaya, G.V. and Ordan'yan, S.S., Poroshkovaya metallurgiya, No. 6, 53, 1967.
2. Deryagin, B.V., Kolloidi Zh., 7, 285, 1941; Works of the Third All-Union Conference on Colloid Chemistry. Moscow, USSR Academy of Sciences, 1956, p. 225.
3. Dobrovol'skiy, A.C., "Slip Casting," Metallurgizdat, Moscow, 1967.
4. Eremenko, B.V., Lyubchenko, I.N. and USKOV, I.A., "Physico-chemical Mechanics and the Lyophilic Nature of Dispersed Systems," Vol. 3, 1971.
5. Kosolapova, T. Ya., "Carbides," Metallurgizdat, Moscow, 1968.
6. Chernoberezhskiy, Yu. M., Kuleshova, L.N., and Kolesnikova, L.I., Vestnik Leningradskogo Unta., No. 10, 114, 1969.
7. Ahmed, S.M., Can. J. Chem. 44, 1663, 1966.
8. Parks, G.A. and de Bruyn, P.L., J. Phys. Chem., 66, 967, 1962.