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ELECTRIC CONDUCTIVITY OF KAOLIN IN THE TEMPERATURE RANGE 150–560°C

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Abstract

The *dc* conductivity of kaolin (Sedlec and Podbořany) used in electrical insulator technology was measured in temperature cycles between 150 and 560°C after preheating at 150°C/30min. The heating and cooling rates were 5°C min^{-1}. Dehydroxylation was accompanied by a temporary fall in the *dc* conductivity as a consequence of the reaction between removed OH^- groups. The changes in *dc* conductivity over the temperatures used were explained by the migration of Ca^{2+}, Na^+ and K^+.

Keywords: electric conductivity, kaolin

Introduction

The electrical properties of electroporcelain, which is widely used as an insulator material, have been repeatedly measured under different conditions. On the other hand, the electrical properties of green porcelain body and kaolin have been measured only rarely. The conversion of kaolinite into metakaolinite at temperatures above 800°C has been studied by measuring their electrical resistance [1]. The influence of the partial pressure of water vapour and also of temperature were described in [2]. The liberation of the physically bound water was investigated by measuring the temperature dependences of the electrical parameters [3]. The liberation of the chemically bound water was investigated by electric conductivity measurements in [5].

The present paper deals with the temperature dependence of the *dc* electric conductivities of some kaolins mostly used in insulator technology in the Czech Republic and Slovakia.

Experimental

The studied samples of kaolins originate from two deposits in the Czech Republic. Their chemical compositions are given in Table 1.

Direct current conductivity was measured with a dynamic electrometer (VK2-16, USSR). The electromagnetically shielded sample was located in a cy-

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Table 1 Measured kaolins and their compositions [%]

	KS	KP	KPA
H_2O	12.8	11.2	11.3
SiO_2	48.2	55.6	55.2
Al_2O_3	35.8	29.9	30.7
Fe_2O_3	0.7	0.7	0.6
TiO_2	0.4	0.4	0.3
CaO	0.6	0.4	0.3
MgO	0.3	0.5	0.5
K_2O	1.1	1.1	1.0
Na_2O	0.1	0.2	0.1

KS = Sedlec kaolin, KP = Podbořany kaolin, KPA = activated Podbořany kaolin.
The KP kaolin sample was activated by chemical treatment in the delivery factory.

lindrical furnace in air atmosphere. The temperature was controlled by the temperature programmer, with a heating/cooling rate of 5°C min^{-1}.

Cylindrical samples (diameter 9 mm, thickness 3 mm) were prepared by sedimentation of the kaolin suspension in gypsum casting forms. After their preparation and drying at 150°C for 30 min, colloidal graphite electrode coatings were deposited on both bases of the sample at 90°C.

After deposition in the furnace, the sample was heated at 150°C for 30 min. This thermal exposure was sufficient for removal of the bulk of the physically bound water. Its removal was confirmed via the electrical current measured with the electrometer.

Results and discussion

The results of measuring the dependence of *dc* electric conductivity on temperature are shown in Fig. 1. The sample was heated from 140°C to the temperature of the start of its dehydroxylation (340°C for KS, and 430°C for KP and KPA). The dependence $\sigma(1/T)$ in Fig. 1 reveals the existence of two mechanisms of electric conductivity during heating of the sample. Similarly, two mechanisms exist in the cooling region. The dependences $\sigma(1/T)$ in the cooling region, measured in repeated heating–cooling cycles, are equivalent to the dependence relating to the first cooling.

The increase in electric conductivity at temperatures lower than 260°C can be explained by the superposition of the liberation of the residual physically bound water (transport of H^+ and OH^-) [2, 4] and by the migration of Ca^{2+}, Na^+ and K^+ [5].

From this temperature to the temperature of the start of dehydroxylation, the increase in the electric conductivity is caused by the migration of Ca^{2+}; Na^+

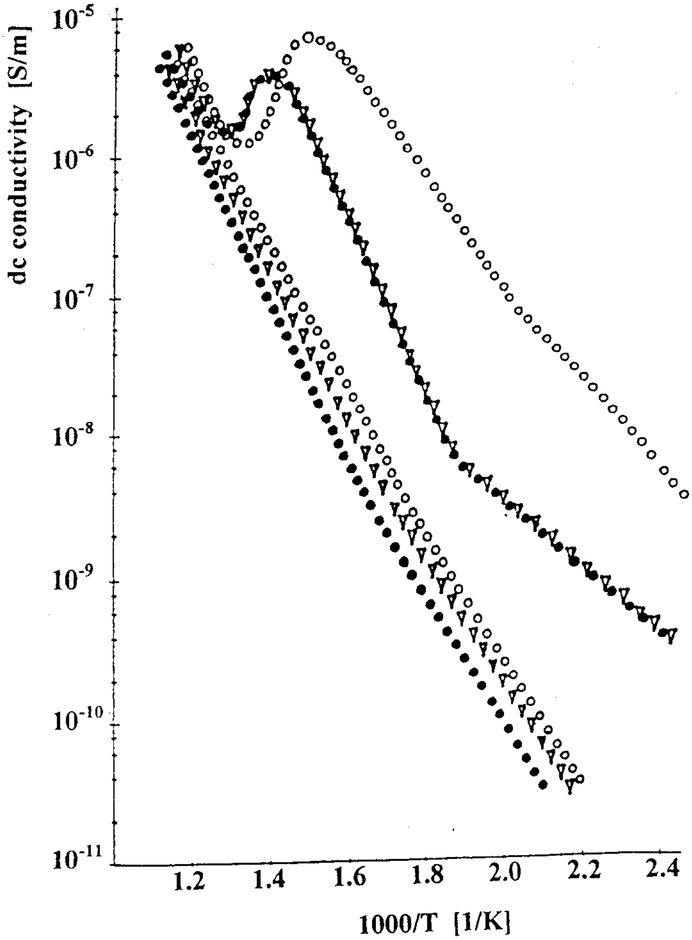

Fig. 1 Temperature dependence of the *dc* conductivity; o – KS, ∇ – KPA, • – KP

and K^+. During dehydroxylation, two opposite processes take place. The first process is removal of OH^- groups from the kaolinite lattice, which could increase the measured *dc* conductivity. The second process is a reaction between these OH^- groups and protons, leading to water vapour. This can decrease the number of charge carriers [2, 3]. A temporary fall in *dc* conductivity is observed in the region of dehydroxylation. After its completion, the *dc* conductivity increases as a consequence of the above-mentioned ion migration.

Conclusions

The changes in the temperature dependence of the *dc* conductivities of the three industrial kaolins used in the Czech Republic and Slovakia (Sedlec, Podbořany and activated Podbořany kaolin) up to dehydroxylation are explained by liberation of the physically bound water and the migration of Na^+, K^+ and Ca^{2+} and by the reaction between OH^- groups and protons.

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