

**INVESTIGATION OF HIGH PURITY ALUMINA CERAMICS  
CORROSION IN ACID AND BASIC AQUEOUS SOLUTIONS BY  
MEASURING SURFACE ROUGHNESS**

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**ABSTRACT**

*There are two basic components in all corrosion tests: the solid specimen and the test environment. The aim of this study was to investigate the surface roughness and type of corrosion of alumina ceramics in acid as well as basic environment. For those reasons test samples of high purity alumina ceramics were prepared by cold isostatic pressing. Test samples were exposed to 2, 10 and 20 wt. % of H<sub>2</sub>SO<sub>4</sub> and NaOH aqueous solution, respectively at room temperature. The roughness parameters of each sample were measured on three spots before and after exposure to H<sub>2</sub>SO<sub>4</sub> and NaOH aqueous solution to determine the difference of corrosion behaviour of high purity alumina ceramics. The type of corrosion of high purity alumina ceramics in acid and basic environment was discussed.*

**Keywords:** alumina ceramics, corrosion resistance, roughness parameters.

**1. INTRODUCTION**

Aluminium oxide, Al<sub>2</sub>O<sub>3</sub> often more referred to as alumina, is an exceptionally important ceramic material, which has many technological applications. Alumina has different phases, of which  $\alpha$ -alumina is a stable phase. It has several special properties like high hardness, chemical inertness, wear resistance and melting point. Alumina is used in many refractory materials, grinding media, cutting tools, high temperature bearings, and a wide variety of mechanical parts [1].

It is often said that one of the biggest advantages which ceramics have over other materials is their corrosion resistance, e. i. their chemical inertness in corrosive environments.

Corrosion resistance depends on the properties of the corrosive medium, the chemical composition and microstructure of ceramics, and conditions of the corrosive process [2, 3].

The monitoring of corrosion in aqueous solutions is usually performed by checking mass and/or strength change after immersion into a fixed volume of corrodent. In this study we have investigated the corrosion behaviour of high purity alumina ceramics based on measuring the roughness parameters before and after exposure to different concentrations of H<sub>2</sub>SO<sub>4</sub> and NaOH aqueous solution, respectively at room temperature.

## 2. MATERIALS AND METHODS

The material used in the corrosion tests in  $H_2SO_4$  and  $NaOH$  solutions was a cold isostatically pressed (CIP)- $Al_2O_3$  with 99.8 % purity.  $Al_2O_3$  ceramic contains  $MgO$  as sintering aid and usual impurities  $SiO_2$ ,  $CaO$ ,  $Na_2O$  and  $Fe_2O_3$ . The CIP- $Al_2O_3$  specimens were supplied by Applied Ceramics, Inc., Fremont, California, U.S.A. The specimens were rectangular coupons; size was  $0.8\text{ cm} \times 1.0\text{ cm} \times 2.0\text{ cm}$ .

Each surface of  $Al_2O_3$  specimens was polished. After polishing, and before the corrosion tests, samples were thoroughly cleaned with hot distilled water in the ultrasonic bath (UltraSonic Bath Model 1510 DTH, Electron Microscopy Sciences, Hatfield, USA), dried in the sterilizer (Instrumentaria, Zagreb, Croatia) at  $150 \pm 5\text{ }^\circ\text{C}$  for 4 hours. The roughness of each sample was measured on three spots by means of Perthometer S&P 4.5, (Feinprut Perthen GmbH, Goettingen, Germany). In the  $H_2SO_4$  and  $NaOH$  corrosion tests, the specimen and a 5 ml of  $H_2SO_4$  and  $NaOH$  solutions were put into a sealed polypropylene (PP) tube, respectively. The corrosive environments were  $H_2SO_4$  and  $NaOH$  solutions concentrations of 2, 10 and 20 % at room temperature ( $25\text{ }^\circ\text{C}$ ) for 30 days. Then, the samples were removed from the polypropylene (PP) tube, washed and dried. The roughness was measured again.

## 3. RESULTS AND DISCUSSION

Diagrams of roughness profile of alumina ceramics before and after 30 days exposure to corrosive environments of  $H_2SO_4$  and  $NaOH$  solutions concentrations of 2 wt. % at room temperature ( $25\text{ }^\circ\text{C}$ ) are shown on Figure 1 and 2.

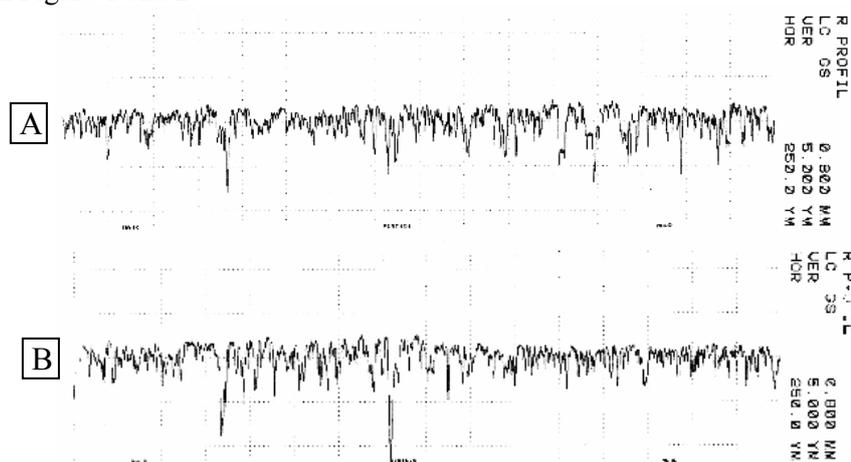


Figure 1. Roughness profile of alumina ceramics before (A) and after (B) immersion in 2 wt. % of  $H_2SO_4$  aqueous solution.

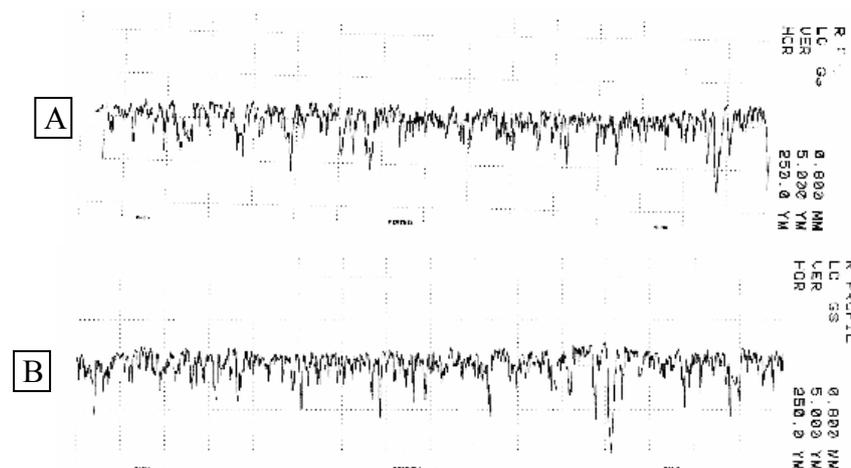


Figure 2. Roughness profile of alumina ceramics before (A) and after (B) immersion in 2 wt. % of  $NaOH$  aqueous solution.

Figure 3 show results of values of the maximum surface roughness ( $R_y$ ,  $\mu\text{m}$ ) of alumina ceramics before and after immersion in different concentration of  $\text{H}_2\text{SO}_4$  and  $\text{NaOH}$  aqueous solution, respectively at room temperature. Figure 4 show results of values of the average roughness ( $R_a$ ,  $\mu\text{m}$ ) of alumina ceramics before and after immersion in different concentration of  $\text{H}_2\text{SO}_4$  and  $\text{NaOH}$  aqueous solution, respectively at room temperature.

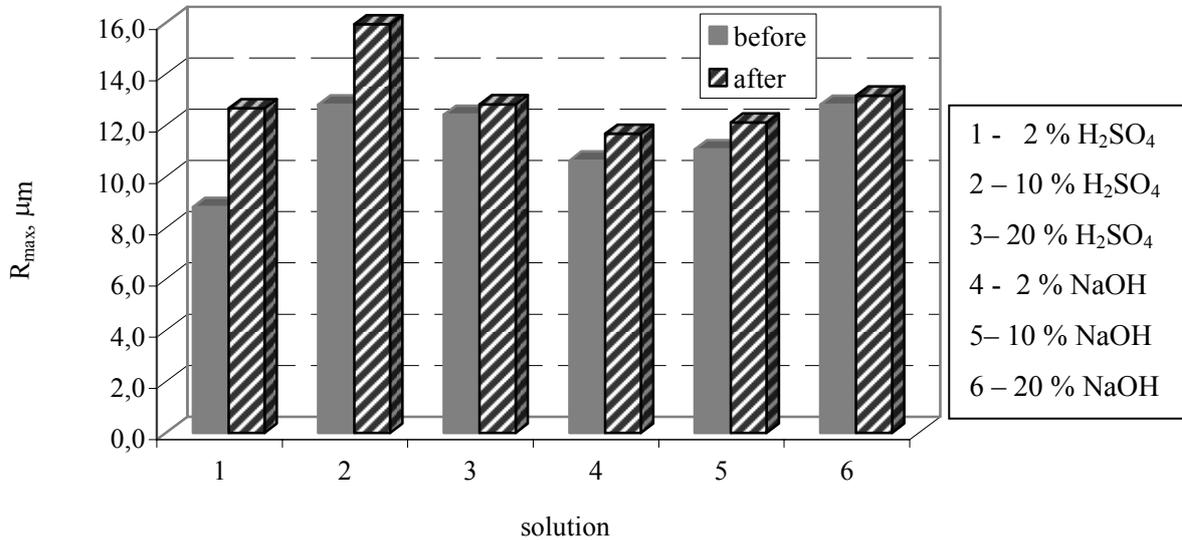


Figure 3. Values of the maximum surface roughness ( $R_y$ ,  $\mu\text{m}$ ) of alumina ceramics before and after immersion in 2, 10 and 20 wt. % of  $\text{H}_2\text{SO}_4$  and  $\text{NaOH}$  aqueous solution, respectively at room temperature.

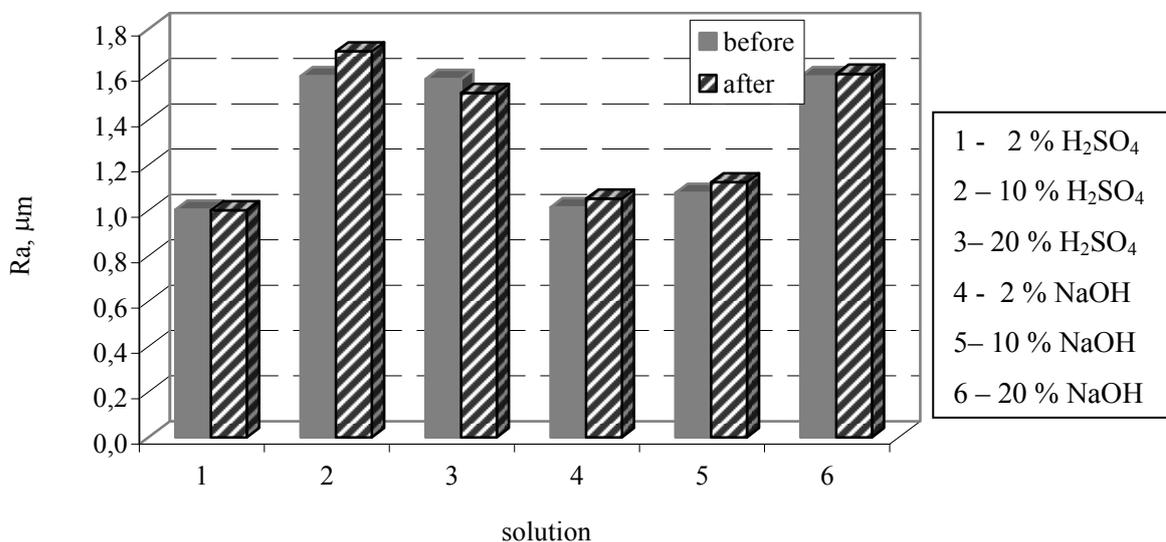


Figure 4. Values of the arithmetic mean deviation ( $R_a$ ,  $\mu\text{m}$ ) of alumina ceramics before and after immersion in 2, 10 and 20 wt. % of  $\text{H}_2\text{SO}_4$  and  $\text{NaOH}$  aqueous solution, respectively at room temperature.

Obtained results show that the values of the maximum surface roughness ( $R_y$ ,  $\mu\text{m}$ ) increase after exposure to aqueous solution of acid ( $\text{H}_2\text{SO}_4$ ) and base ( $\text{NaOH}$ ). Variations of initial of  $R_y$  values are higher in acid ( $\text{H}_2\text{SO}_4$ ) than in basic ( $\text{NaOH}$ ) environment. Also, this variation is more significant at

lower concentration of acid and base. Diagrams of roughness profile show significantly higher corrosion penetration depth (maximum roughness depth) in certain areas after exposure of 2 wt. % of H<sub>2</sub>SO<sub>4</sub> (Figure 1 B) compare to the beginning condition (Figure 1 A). It is assumed that these areas are the sites of segregation of impurities at the grain boundaries. Results of investigations of other authors show that these areas are the most susceptible to corrosion process, what is in correlation with the previous assumption [4].

Values of the arithmetic mean deviation ( $R_a$ ,  $\mu\text{m}$ ) do not show changes, compared to the initial values, neither in acid, nor in basic solution.

#### 4. CONCLUSION

Results of changes of mentioned roughness parameters show that Al<sub>2</sub>O<sub>3</sub> ceramics possess higher chemical stability in NaOH aqueous solution than in H<sub>2</sub>SO<sub>4</sub>, with the same initial concentrations. Higher corrosion penetration depth in certain areas after exposure of 2 wt. % of H<sub>2</sub>SO<sub>4</sub> was observed, which is in correlation with the results of investigation of other authors. Obtained results are also in conformity with the results obtained by measuring the concentration of eluted ions of Al<sup>3+</sup>, Mg<sup>2+</sup>, Si<sup>4+</sup>, Ca<sup>2+</sup>, Fe<sup>3+</sup> and Na<sup>+</sup> in eluate after immersion in acid and basic aqueous solution [6, 7].

#### 5. ACKNOWLEDGMENTS

The presented research results were achieved within the scientific project "Structure and properties of engineering ceramics and ceramic coatings" (Agreement No 120-1201833-1789; 10106-797300-1) supported by the Croatian Ministry of Science, Education and Sport. We thank Matt Sertic from Applied Ceramics, Inc. for providing alumina ceramics samples.

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