Proceedings of the
International Conference on Mechanical Engineering and Renewable Energy 2019
(ICMERE2019) 11 – 13 December, 2019, Chittagong, Bangladesh

ICMERE2019-PI-097

CORROSION BEHAVIOR OF SILICON-BASED CERAMICS IN ALKALINE AND GREEN SOLUTION

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Abstract*- This paper represents the corrosion behavior of silicon based ceramics that composed of silicon, aluminum, magnesium and iron in NaOH and Neem leaf juice to obtain suitable less corrosive solution. Four different solutions such as NaOH of Ph value of 12.65; Neem leaf juice of Ph value of 4.15; 60% NaOH,40% Neem leaf juice of Ph value of 8.3 and 40% NaOH ,60% Neem leaf juice of Ph value of 7.7 are considered. Firstly the weights of the four samples are taken. Then they are kept in four different solutions for 30 days. Later the weight of each sample is measured and compared with the previous weight. Weights of the samples 1, 2 and 4 are increased about 0.01%, 0.04% and 0.005% respectively while weight of sample 3 is decreased 0.009%. Finally, morphological analysis of the samples is performed by SEM to investigate the abnormality in sample's structure.*

Keywords: corrosion, alkaline, green solution, morphology.

1. INTRODUCTION

Corrosion behaviors of porous reaction-bonded silicon carbide (RBSC) ceramics incorporated with CaO has been investigated. The porous RBSC ceramics showed excellent corrosion resistance in acid and basic solutions. The maximum anti-oxidation temperature of the porous RBSC ceramics is 1473 K in presence of air. The bending strength of RBSC ceramics is 17.5 MPa after 60 cold-hot cycles in air (273–1073 K). The porous RBSC ceramics also revealed relatively good corrosion resistance in molten salts (NaCl, Na_2SO_4 and $CaCl_2$). SiO_2 layers have been broken on the SiC surface in Molten NaOH [1].

Corrosion behavior of TiC–SiC composite ceramics in molten FLiNaK Salt showed small mass loss and relatively good corrosion resistance in molten FLiNaK salt. The corrosion forms of $TiC_{0.8}$, TiC, TiC–20 vol% SiC and TiC–40 vol% SiC were inter-granular corrosion, which were resulted from the reduction of Ti along the grain boundaries. A general corrosion process of SiC in which a carbon rich layer was formed on the surface, resulting from the reduction of Si. The carbon-rich layer protected SiC against further corrosion, hence lowering the corrosion rate. The corrosion results of TiC–20% SiC and TiC–40% SiC revealed that by adding SiC the corrosion resistance of TiC could be improved [2].

The corrosion behavior of silicon nitride (Si_3N_4) ceramics with a porosity of 46% at 1473–1773 K under different conditions including dry O_2, O_2 containing 20 vol% H_2O and Ar containing 20 vol% H_2O is investigated and compared. The results show that porous Si_3N_4 ceramics has a good oxidation resistance up to 1473 K. Their corrosion behavior depends on the temperature and atmosphere. The morphology of reaction product is highly affected by water vapor and thus accelerate the corrosion rate due to its specific inward diffusion mechanism and devitrified effect at high temperature [3].

Sintered silicon carbide ceramics have found widespread use due to their high corrosion stability. Seals, bearings and valves in industrial wear applications are made by silicon carbide materials and solid state-sintered silicon carbide materials (SSiC) [4]. This corrosion stability can be affected by electrochemical processes. Electrochemical corrosion experiments conducted on an SSiC material in NaOH at different voltages and subsequent detailed investigation of the formed surfaces were carried out. Systematic local measurement of the corrosion rate was carried out using the AFM technique. The results revealed the recession of the SiC grain surfaces under anodic electrochemical loading, with the extents differing strongly from grain to grain. The decline rates were not found to correlate with the SiC grain orientations or polytypes. But, the data and the observed microstructure indicated that the behavior was caused by variations in the resistivities of the grain boundaries [5]. Meanwhile same materials have been utilized to investigate the electrochemical corrosion behavior using H_2SO_4 at same conditions as mentioned earlier. The first time a systematic local measurement of the thickness of the oxide layers was carried out. The measurements showed the formation of SiO_2 surface layers with thickness up to 125 µm. The measured values also showed a strong deviation from grain to grain. The thickness of the layers does not correlate with the crystallographic orientation of the grains or the SiC-poly types. The data indicate that the behavior is caused by the variation of the resistivity of the grain boundaries. The measured thicknesses as a function of the electrical charge transferred indicate that the electrochemical oxidation results in the $SiO_2$and carbon dioxide.

This article focuses on to investigate the corrosion behavior of a novel composition of silicon based ceramics in various liquid mediums such as NaOH and Neem leaf juice as the applications of ceramics materials are increasing day by day.

2. METHODOLOGY

The samples for the experiment are prepared by the combination of Magnesium, Aluminium, Silicon and Iron. The chemical compositions for the samples are illustrated in table 1:

Table 1: Chemical composition of samples (wt%).

Mg	Al	Si	Fe
2.56±1.00	31.05±0.56	64.12±0.80	2.26±0.20

The samples are prepared through several processes. Powders of above mentioned composition are mixed together followed by liquefying them. This liquid composition is passed the rolling process in order to obtain uniformity of the composition. The rolling process has been carried out about 30 minutes. Then casting process has been completed by pouring the liquid composition into the mold cavity and leaves it for 4 hours to become solid. Finally, hardening process has been carried out at 1573 K for 6.5 hrs.

Four different solutions have been used for this research. NaOH solution is collected from laboratory and its Ph value is measured. The measured Ph value is about 12.65 that indicate strong alkaline characteristics of NaOH solution. Locally collected Neem leaves are washed and dried followed by blending to obtain juice. The measured Ph value of the prepared Neem juice is about 4.15 that indicate lean acidic characteristics of the juice. Other two solution of this research are 60 wt% NaOH, 40 wt% Neem juice with ph value is about 8.3 and 40 wt% NaOH, 60 wt% Neem juice with ph value is about 7.7. Four samples are immerged into the four different solutions. Table 2 illustrates the samples and their corresponding solutions.

Table 2: Samples with Ph value

Samples	Solution	Ph value
Sample – 1	NaOH (100%)	12.65
Sample – 2	NaOH (60%) + Neem leaf juice (40%)	8.3
Sample – 3	NaOH (40%) + Neem leaf juice (60%)	7.7
Sample – 4	Neem leaf juice (100%)	4.15

When the ceramic sample is kept in the sodium hydroxide solution, sodium hydroxide reacts with the components of ceramic and produces sodium ion in the solution. Some other compounds are formed with the ion such as magnesium oxide, aluminum oxide, silicon oxide, iron oxide. In each chemical reaction electron is produced which indicates the electrochemical corrosion in alkaline solution [6,7,8]. The following mechanism may happen during the time of corrosion:

$NaOH + Mg = Mg(OH)_2 + Na^+ + e^-$

$NaOH + Al = Al_2O_3 + Na^+ + e^-$

$NaOH + Si = Si_2O_3 + Na^+ + e^-$

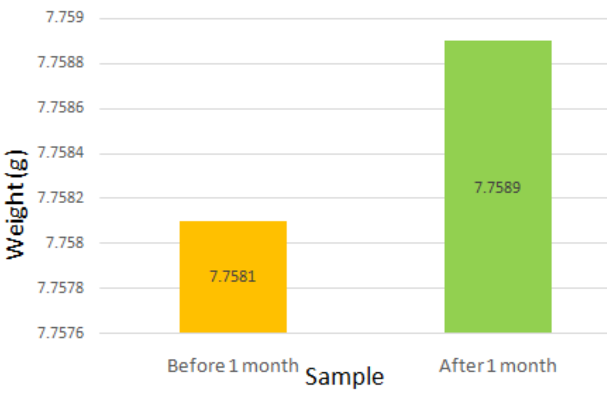
$NaOH + Fe = Fe_2O_3 + Na^+ + e^-$

Figure 1 shows the samples after extracting form solutions.

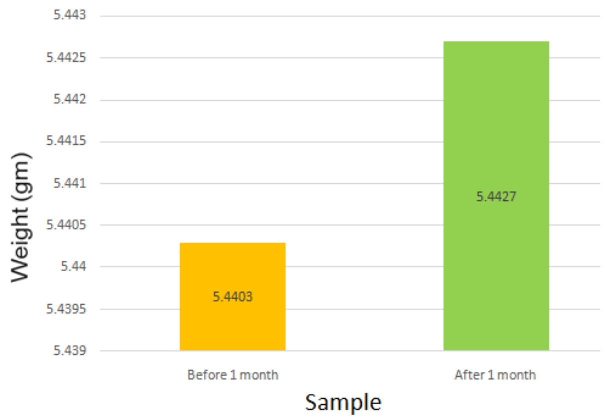
Figure 1: samples after extracting from solutions

3. RESULT AND DISCUSSION

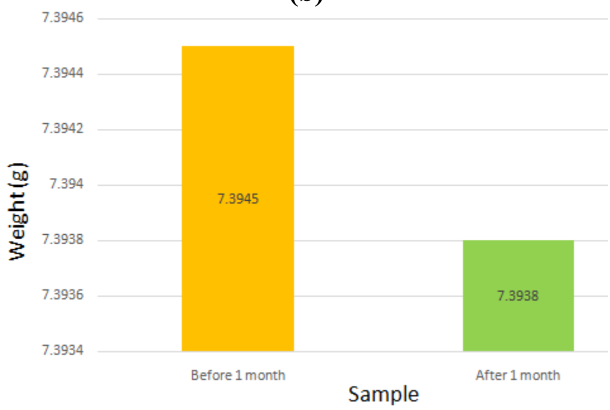
Figures 2(a), 2(b) and 2(d) indicate the slight increment of weight after the experiments. Sample-1, sample-2 and sample-4 increased weights about 0.008gm, 0.0024gm and 0.003 gm respectively. Fast infiltration due to capillary action [14, 15] might cause to gain the weight of the samples. Unlike figure 2(a) ,2(b) 2(D), the weight of the sample 2(c) decreased about 0.0011 gm. The reason for the weight loss might be the chemical reaction of the solution of NaOH and leaf with the ceramic sample and the formation of sodium ion and acid [1,9]. Besides, the dissolution of SiO_2 phase probably played a significant role to decrease the weight of the sample 2(c) [14].



(a)



(b)

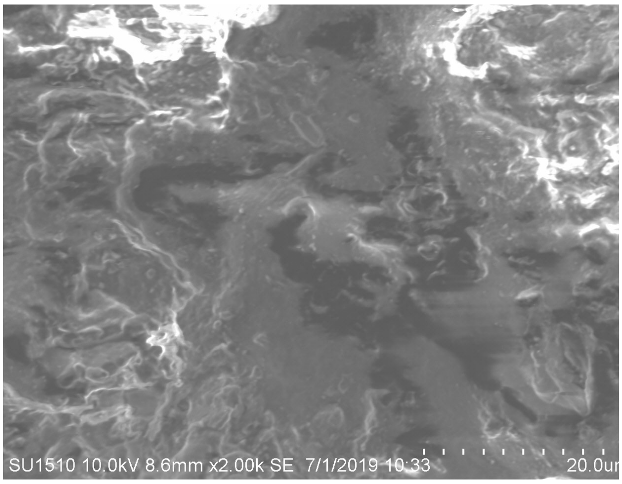


(c)

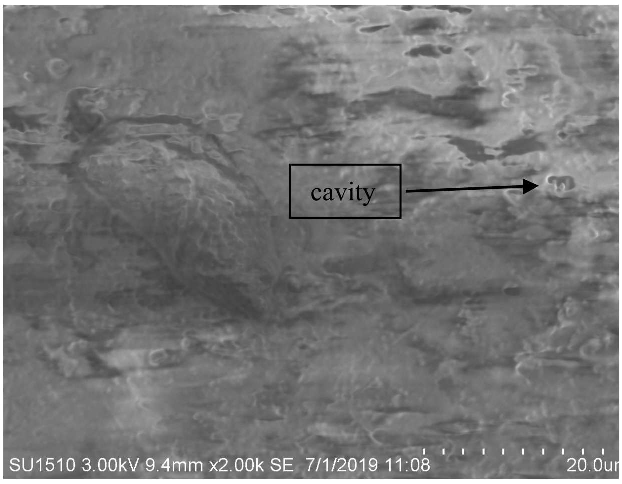
(d)

Figure-2: Comparison of weight of the samples before and after the experiment (a) NaOH, (b) 60% NaOH and 40% neem, (c) 40% NaOH and 60% neem and (d) neem.

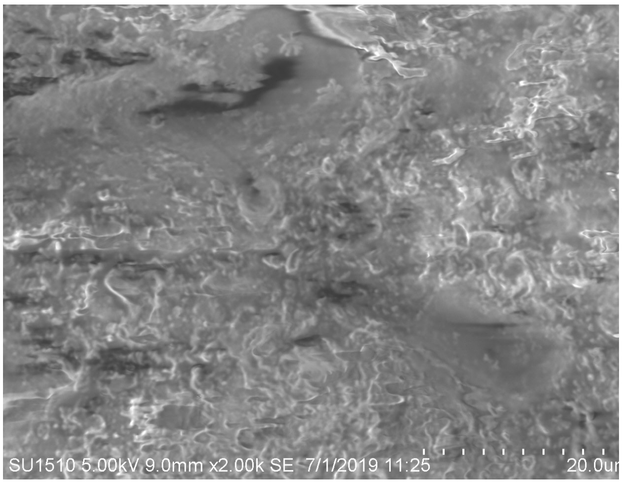
Fig. 3 shows surface SEM micrographs of the corrosion layer produced by the solutions in one month of the corroded ceramics. A thin and homogeneous layer was produced on the ceramic surface. The surface was partially covered by oxide layer [12,13]. Because of being remained under liquid solution for a long period of time few cracks were formed which indicates the surface is corroded [10,16]. Corroded surface produced by the alkaline is seen in figure 3(a). Some cavities are formed in figure 3(b) [11,]. Layers of alkaline and neem juice are seen in figure 3(c). Thick layer of neem juice is formed in figure 3(d).



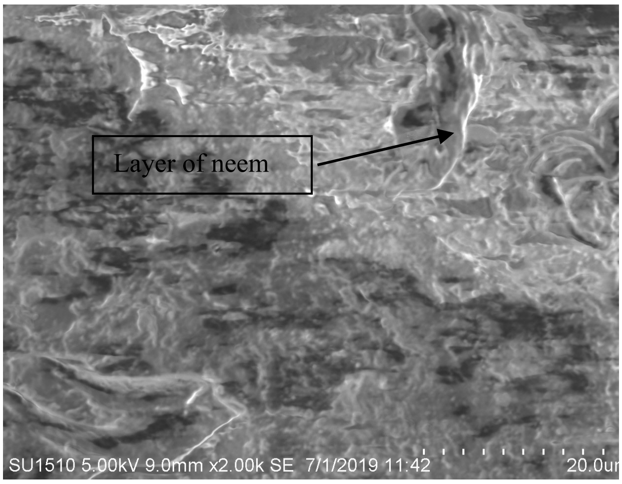
(a)



(b)



(c)



(d)

Figure-3: Surface morphology of different samples after corrosion testing in the solution of (a) NaOH, (b) 60% NaOH and 40% neem, (c) 40% NaOH and 60% neem and (d) neem.

4. CONCLUSION

The purpose of the corrosion test of silicon based ceramic in the solution of sodium hydroxide, Neem leaf and their mixture was to find a suitable solution that makes less corrosion on ceramic. After the experiment it was found that the Neem leaf juice produces less corrosion on ceramic compared to NaOH solution. The weight of all the samples increases except the sample 3. In order to obtain more suitable solution, more green solution can be addressed for the experiment.

5. ACKOWLEDGEMENT

The authors acknowledge all the supporting members in Mechanical Engineering laboratory and Chemical laboratory of College of Engineering and Technology, IUBAT-International University of Business Agriculture and Technology to complete the research and the management of FARR CERAMICS Ltd. for their permission to prepare the research samples.

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7. NOMENCLATURE

Symbol	Meaning	Unit
T	Temperature	(K)
P	Pressure	(Pa)