ISSN 2229-5518

Electrophoretic Deposition of Silica on Stainless Steel

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Abstract—Fabrication of stainless steel-silica composite was successfully done using Direct Current Electrophoretic Deposition. Deposition of silica particles on stainless steel substrate was conducted in an aqueous suspension with 0.001M Sodium Nitrate as background electrolyte, 30V constant voltage and a deposition time of 5 and 10 minutes. Characterization of the samples showed randomly distributed silica particles for 5 minutes deposition time and aggregated silica particles for 10 minutes deposition time.

Index Terms— particle size analysis, scanning electron microscopy, EPD

1 Introduction

ELECTROPHORETIC DEPOSITION was discovered by a Russian Scientist named Rues in early 19th century in his experiment with electric field to induce motion of clay particles suspended in water [1]. First commercialization of this method is patented in the USA in early 1930's with the deposition of thoria on a platinum cathode for electron tube applications and only in 1980's did the method received unique recognition for fabrication of advanced ceramic materials [2]. Important applications of these electrophoretically deposited advanced ceramic materials could be found in fuel cells, optics, bioceramics, photonics, and electronics. Aside from ceramic materials [3], this method had already been adopted in almost all materials like metals [4], polymers [5] and composites [6].

Advantages of EPD method lie in its simplicity and inexpensiveness. EPD set up could easily be fabricated using low costs materials. The simplest design consists only of two parallel conducting plates as electrodes, container of suspension, and dc battery, as voltage source to facilitate migration of particles. Aside from simplicity and inexpensiveness, EPD is a fast method which made it attractive in industries for it is suitable for mass production.

The objective of this study is to fabricate a composite material consists of metal and ceramic oxide. In particular, the researcher investigated the possibility of using electrophoretic deposition method in fabricating a composite material made up of stainless steel and silica. It is known that both materials have important biomedical applications [7-9] and its composite is an important high temperature material [10-11]. A fast method suitable for mass production of stainless steel-silica composite is

2 Experimental Procedure

2.1 Particle Size Analysis

Industrial grade 98% purity silica powder from Dalisay Philippines Corporation was prepared by sieving the particles using 270, 325 and 400 meshes in a mechanical shaker prior to suspension preparation. Five grams (5g) of sample from each mesh were then analyzed using Coulter Counter to evaluate its particle sizes and distribution.

2.2 Suspension Preparation

Suspension for Electrophoretic Deposition was prepared by weighing 50 mg of the analyzed silica powder and then pouring it in a 1L 0.001 M Sodium Nitrate Solution. The resulting suspension was then ultrasonicated for 6 minutes prior to Electrophoretic Deposition to prevent aggregation and settling of particles.

2.3 Electrophoretic Deposition

Electrophoretic deposition was done by setting up rectangular stainless steel electrodes with 10mm x 10mm dimensions, 10 mm apart in a fabricated electrophoretic deposition cell. The ultrasonicated silica suspension was then poured in the EPD cell. After which, a constant voltage of 30V was then applied for 5 minutes and 10 minutes. The sample was then air dried before characterization.

2.4 Characterization

Scanning Electron Microscope was used to view and image the stainless steel substrate and the electrophoretically deposited silica. Micrographs for each sample were then taken at 2,000 X and 10,000 X magnifications to view the overall surface of the sample and its details.

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3 Results and Discussion

This study focused on the possibility of producing stainless steel-silica composite using electrophoretic deposition method. Deposition of silica particles on stainless steel substrate was done under constant voltage of 30V for 5 and 10 minutes in an aqueous suspension using 0.001M sodium nitrate as background electrolyte. After deposition, samples were then observed and imaged using Scanning Electron Microscope (SEM) to characterize the morphology of the deposited silica particles on stainless steel substrate.

3.1 Particle Size Analysis

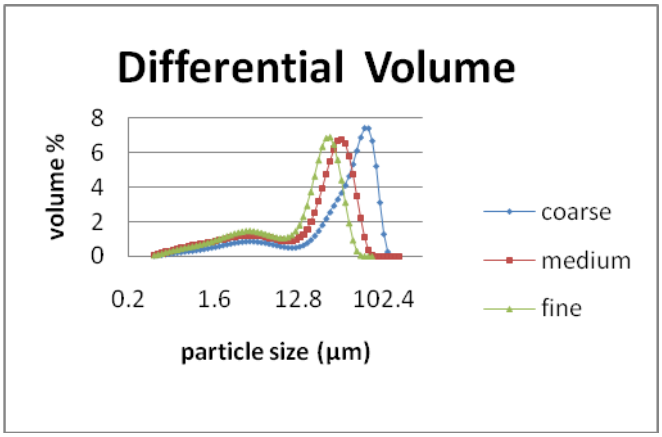

Fig. 1. Particle size distribution of silica particles after sieving using 270, 325 and 400 mesh

Industrial grade 98% purity silica powder from Dalisay Philippines Corporation was prepared by sieving the particles using 270, 325 and 400 meshes in a mechanical shaker prior to suspension preparation. Five grams (5g) of sample from each mesh were then analyzed using Coulter Counter to evaluate its particle sizes and distribution.

3.2 Scanning Electron Microscopy (SEM) Analysis

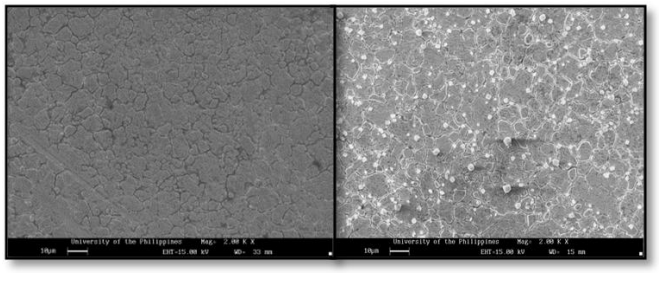

Fig. 2. SEM micrograph showing the surface of stainless steel and the overall feature of the randomly distributed silica particles on stainless steel substrate taken at 2000 X magnification

The SEM micrograph on the left hand side is the surface of stainless steel substrate before deposition of silica particles. SEM micrograph on the right hand side on the other hand shows the silica particles on stainless steel after deposition for 5 minutes under 30 V electric potential. It can be observed that these particles are randomly distributed throughout the surface and it vary in amount and sizes. Of these particle sizes, only a minute amount is coarse and the rest are fine particles.

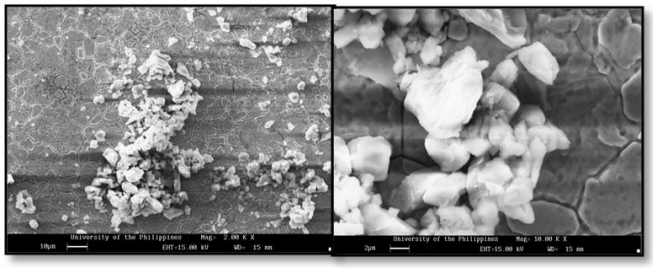

Fig. 3. Electrophoretically deposited silica on stainless steel substrate showing aggregated silica particles taken at 2,000 X and 10,000 X magnifications respectively.

The SEM micrograph on the left hand side shows silica particles after 10 minutes deposition under 30V constant voltage. On this micrograph, it can be observed that a larger portion of the deposited particles are fine and only a little amount of large particles are present. Unlike the micrograph for 5 minutes deposition time, these fine particles are aggregated and not randomly distributed throughout the surface of the stainless steel. A closer view of the micrograph shows these aggregations of fine particles (micrograph on the right). Furthermore, it is also noticeable that for both figures presented, the deposited silica particles are somewhat equiaxed and could therefore be estimated as spherical particles.

4 Conclusion

Fabrication of stainless steel-silica composite in an aqueous suspension was successfully done using a direct current electrophoretic deposition with a constant voltage of 30V for 5 and 10 minutes. SEM micrographs of the samples showed randomly distributed silica particles for the former and aggregated silica particles for the latter.

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