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Metallization of Fly Ash particles using Electroless Cobalt Plating process

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Abstract: The alloy Co–P coatings on hollow fly ash spheres have been successfully synthesized through electro less plating in this paper. The possible mechanism of electroless Co–P coating of cenosphere particles utilizing sodium hypophosphite activator was tried. The existence of Co and Co-P were confirmed by XRD (X-ray diffraction analysis) and SEM (scanning electron microscopy) images. The cenosphere particles were characterized by energy-dispersive spectroscopy (EDX). The recommendation of coated fly ash for various industrial applications is done.
Keywords: fly ash, combustion, XRD, SEM.

Introduction

Since the days Electroless plating has been commonly used in engineering coating applications where wear resistance, hardness and corrosion protection are required.
But not much of the work has been done for the Electroless plating of non conductors i.e. Fly ash. Moreover fly ash is a residue remained after the industrial processes. So by reusing the fly ash, we will be leaving the greener foot print on our environment. It accumulates into soil as waste material and contributes to pollution.

To reduce soil pollution by fly ash, the soil is subjected to recycling process and fly ash is isolated from the soil. The new reusable and profitable materials is produced to prevent environmental problems. Electroless deposition of Co-P alloy on Fly ash particles is done by using sodium hypophosphite as a activator [1-5]. Electroless plating, also known as chemical or auto-catalytic plating, plating uses a redox reaction to deposit metal on an object without the passage of an electric current. The important feature of electroless plating is to make the object to be coated as auto catalytic in nature. Electroless plating is chosen for the coating because it produces uniform deposition on intricate shapes and can be done on non-conducting surfaces as Fly ash is non-conducting.

Experimental

Materials

Fly ash particles were obtained from the Bio-Mass plant in VIT University. Flyash Particles has a low density. The particle size distribution varies from 1 to 20 µm.

Activation of Fly ash

Fly Ash is collected from the bio mass plant. Fly ash is washed by Distilled water and kept in sunlight for drying. The contaminates like soil particles were sedimented and separated by washing.

The dried fly ash particles were degreased with aid of acetone. 5 ml of acetone was put in 100g of fly ash particles and the acetone removes the oily substances. Then it was dried and 50 ml of hydrogen peroxide is taken in a beaker and pinch of palladium chloride was added and stirred well in hydrogen peroxide solution. 60 g of fly ash was added to the above solution. It was an exothermic reaction.

By this process the fly ash was activated. That is the palladium was absorbed on the fly ash particles. Hence the non-metallic surface was prepared for the electroless coating to take place.

Preparing the bath composition

200ml of distilled water was taken in 500 ml beaker.16.5 g of cobalt Sulphate ($CaSO_4$) was added and stir well. Then 100 ml of distilled water was added and 25 g of sodium acetate was added and stir well.

Again 100 ml of distilled water was added and 14g of sodium hypophosphite (NaH_2PO_2) was added and stir well. Solution was kept on magnetic stirrer and solution is then mixed and heated uniformly.

Solution was heated for half hour till the temperature is nearly 75^0C. Hence the bath solution was prepared.

Coating process

Activated fly ash is mixed in bath solution. Then the mixture is kept for half an hour to one hour tod avoid agglomeration of particles. The temperature is maintained to nearly about 75^0C.

The Electro less coating is done.

Cobalt is coated on the activated Fly ash uniformly with liberation of hydrogen gas from the bath.After coating, the solution is kept over heating mantle to evaporate all water contents present in the bath.The mixture is collected and kept in sunlight to get dried cobalt coated fly ash powder.

Then the coated Fly ash is pulverized and collected.

Mechanism of deposition

- $H_2PO_2^- + H_2O \rightarrow H_2PO_3 + 2H + 2e^-$
- $Co^{2+} + 2e^- \rightarrow Co$
- $2H^+ + 2e^- \rightarrow H_2$

Inclusion of elemental P in the Co coating

$H_2PO_2 \xrightarrow{\Delta} P + 2H_2O$

Hence the resultant coating is not pure cobalt. It is an alloy of Co-P being responsible for improved magnetic properties.

Results and Discussions

XRD characterization

Figure 1 showed many feeble peaks and no sharp peaks indicating the amorphous nature of coatings on fly ash along with the presence of non-metals like C, Si and Mn.

Figure 2 have many high intensed and sharp peaks. X rays are scattered in certain directions leading to high intensity peaks leading to crystal structure of Co-P coated fly ash. Common peaks such as at angle of nearly 26° and d=3.35 A indicated fly ash particles and other peaks indicated cobalt on the fly ash[6].

SEM Characterization

The scanning electron microscopy (SEM) analysis of uncoated fly-ash cenosphere particles are presented in Fig.3. It showed that they have spherical surface morphology with particles crowding after coating.

EDAX characterization

The chemical constituents of these particles as revealed by EDAX analysis in Figure 4(a) showed that these particles were mainly composed of mixture of oxides and traces of Mg, Na, Ca, Fe, Si, Al from fly ash.

EDAX analysis of Coated Fly ash particles in Figure 4(b) showed that there are elements like Co, P and other elements like Si, Ca, Al, Fe on coated fly ash. EDAX also confirmed that there was Co-P depostion on the fly ash particles[7-8].

Table 1. The composition of bath used for fly ash coatings

Ingredients	**Optimized Content (g/l)**
$CoSO_4.7H_2O$ (Cobalt Sulphate)	33
$C_2H_3NaO_2$(Sodium Acetate)	50
$NaH_2PO_2.H_2O$(Sodium hypophosphite)	28
Operating conditions	**Optimized Conditions:**
Temperature:	78^0C.
pH:	5.5
Time:	60 min

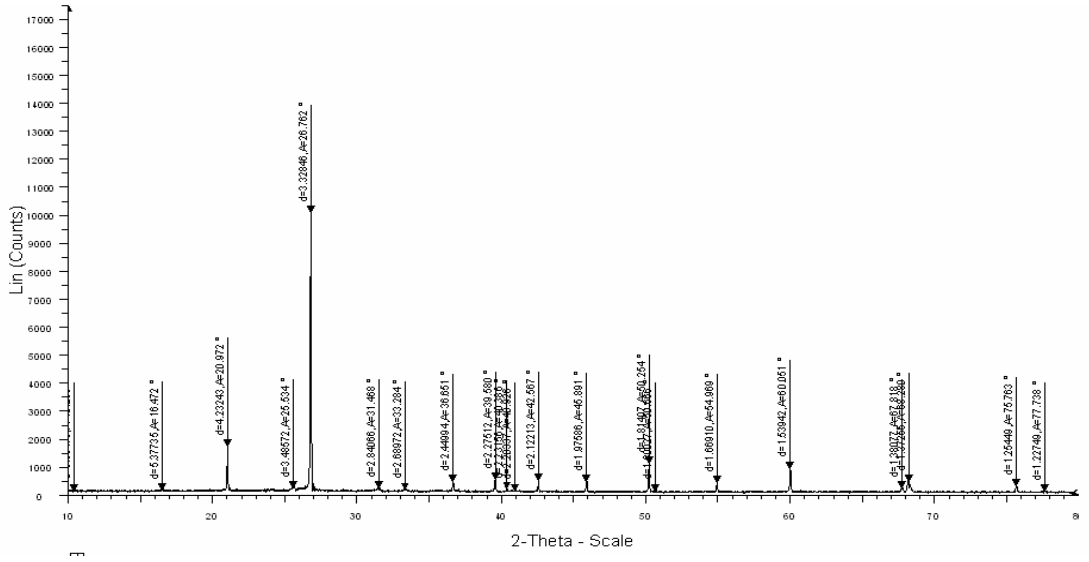

Figure 1 XRD of uncoated fly ash

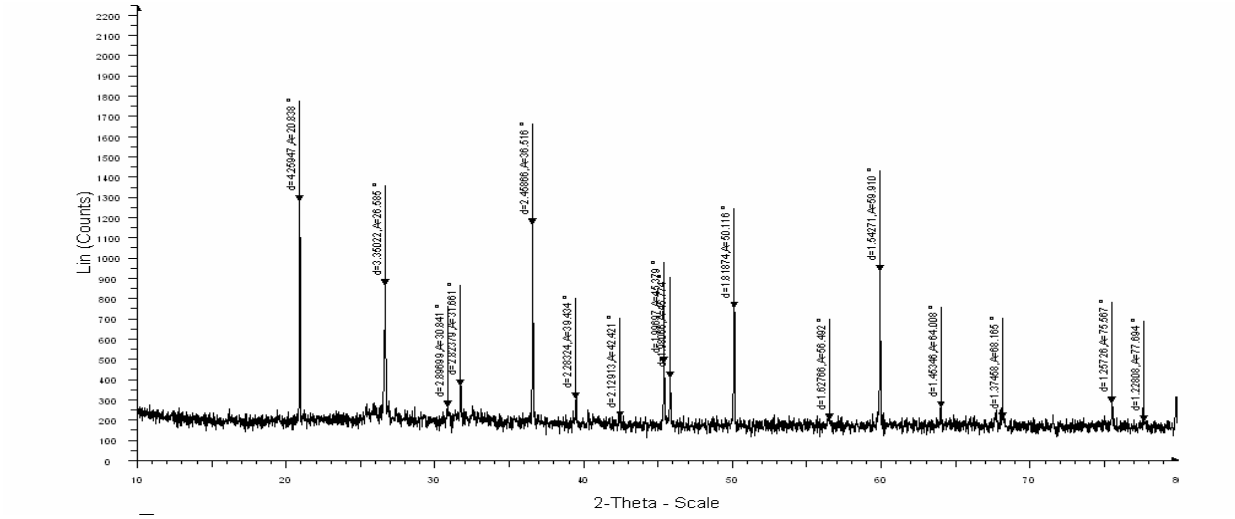

Figure 2 XRD of Co-P coated fly ash

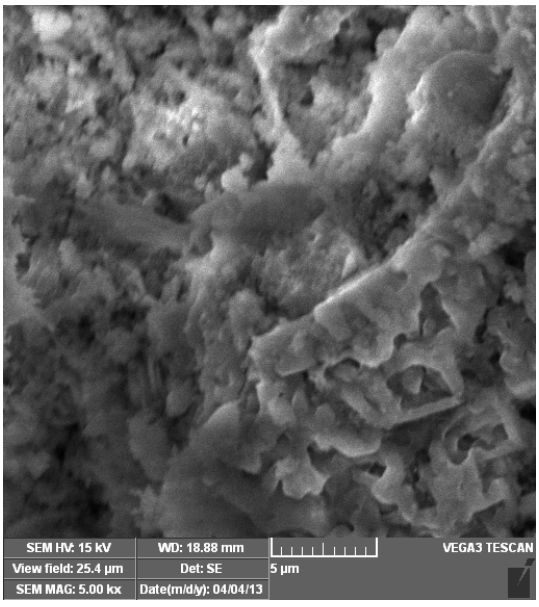

Figure 3(a) Uncoated fly ash

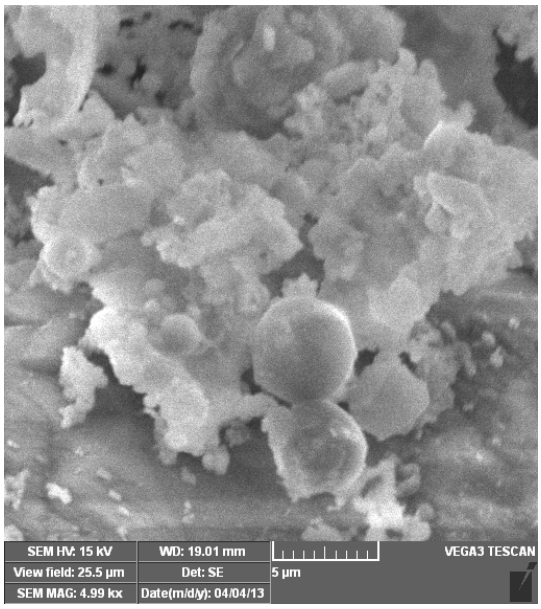

Figure 3(b) Coated fly ash

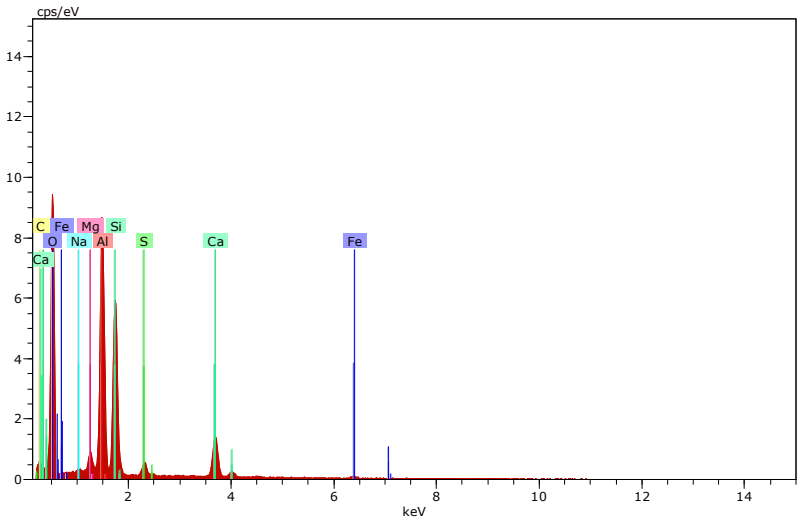

Figure 4(a) EDAX analysis of uncoated fly ash

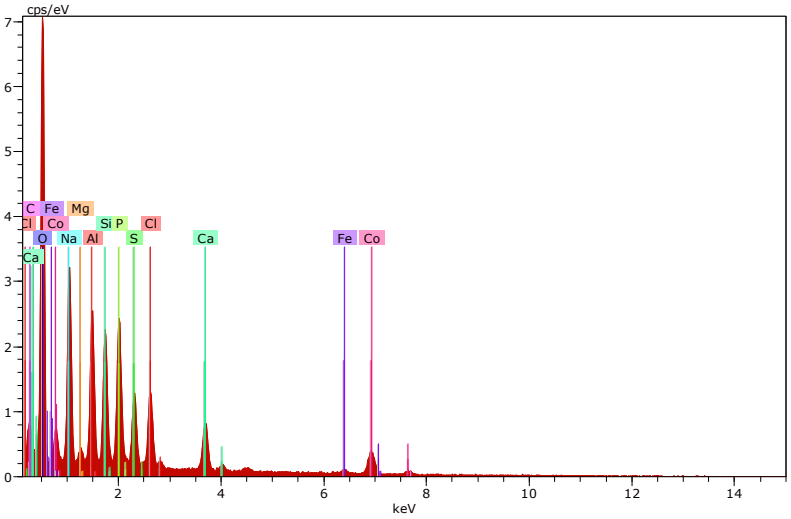

Figure 4(b) EDAX analysis of Co-P coated fly ash

Conclusions

The main conclusions drawn from the present study are

- A suitable bath has been formulated for obtaining metalized fly ash which can be used for many industrial applications.
- Coated fly ash has magnetic properties which can be used for memory drums in electronic gadgets.
- The surface morphology of fly ash particles was carried out by XRD studies.
- SEM-EDAX images confirmed the incorporation of Co-P into fly ash matrix.
- As a whole the coating over fly ash is a good attempt for minimizing the pollution of fly ash accumulation in the soil and atmosphere.
- Fly ash can be chosen as a good substrate for the Electroless coating and coated fly ash can be used for further applications, that is fly ash is been reused.

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