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Effect of Zeta Potential of Stanum Oxide (SnO_2) on Electrophoretic Deposition (EPD) on Porous Alumina

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Abstract. Zeta potential analysis of stanum oxide (SnO_2) aqueous suspensions (pH7 to pH11) was performed prior to the electrophoretic deposition (EPD) of SnO_2. Deposition of SnO_2 on porous alumina was obtained by applying the EPD technique carried out by applying voltage of 18V for duration of four minutes. It was found that the depositions SnO_2 suspended at pH 7 to pH 11 were successful. The relation between the SnO_2 deposition with SnO_2 pH and zeta potential values was established in which increased value of pH causes decreased value of zeta potential and decreased SnO_2 deposition through EPD technique.

Introduction

Electrophoretic deposition (EPD) is an electrochemical coating method which is attracting increasing interest as a material coating technique [1]. It is a process achieved via the motion of charged particles, dispersed in solvent, towards an electrode under an applied electric field [2]. It has been used for the processing and fabrication of a wide variety of advanced ceramic materials and because of the high versatility of use with different materials and their combinations as well as its cost-effectiveness [3] and its ability to produce films on substrate of complex shapes and large dimensions [4]. EPD offers advantages of simplicity, uniformity of deposits, control of deposit thickness, microstructural homogeneity, and deposition on complex shaped substrates, including the potential to infiltrate porous substrates [2].

This coating method manipulates on a number of different parameters such as voltage deposition, time, and the type of coating electrodes suspension. Charged particles of the suspension will migrate to opposite charged to deposit when electrical current is supplied. When the suspended particles are positively charged, deposition occurs on the negative electrode (cathode) *via* a specific EPD process known as cathodic EPD. *Vice versa*, deposition of negatively charged particles on positive electrode (anode) is termed as anodic EPD [3,5].

Zeta potential is one of the main forces that mediate interparticles interaction. Particles with a high zeta potential of the same charge sign, either positive or negative, will repel each other. Conventionally, a high zeta potential can be high in a positive or negative sense, *i.e* <-30mV and >+30mV would both be considered as a high zeta potentials. For molecules and particles that are small enough, and of low enough density to remain in suspension, a high zeta potential will confer stability, *i.e* the solution or dispersion will resist aggregation[6]. In general, pH was widely used as a path to evaluate the charging of particles by modifying zeta potential and thereby the suspension stability so that desirable deposits could be obtained[7].

The present work discloses the effects of stanum oxide (SnO_2) suspension pH and its zeta potential values on the EPD of SnO_2 on a non-conductive substrate. Investigations on EPD of SnO_2 in stable suspensions of acids and alkaline suspension have been performed by various researchers [8] but none have directly compared the SnO_2 deposition with SnO_2 suspension pH and zeta potential on alumina foam.

Experimental Procedure

Zeta Potential Analysis. Aqueous SnO_2 suspension was first prepared by mixing SnO_2 (Aldrich Chemistry, US) powder with distilled water. SnO_2 with solid loadings of 0.5 wt% were used and SnO_2 suspensions of pH 7 to pH 11 were analysed. The pH of SnO_2 suspensions was adjusted accordingly by using nitric acid and ammonia. The SnO_2 aqueous suspensions were then sonicated for five minutes before the zeta potential analysis was conducted.

EPD of SnO_2. SnO_2 suspensions of pH 7 to pH 11 were prepared using the similar procedure as prior to zeta potential analysis. After the EPD of SnO_2 were completed, the alumina foam were dried in oven at 110°C for 24 hours and later sintered at 1000ºC at 2ºC/min for two hours. The weights of the alumina foam prior to EPD and after drying were recorded. Energy Dispersive Spectroscopy *(*EDS) analyses by Scanning Electron microscope (SEM) was also performed on all samples in which 10 points were analysed for each sample.

Result and Discussion

Zeta Potential Analysis of aqueous SnO_2 suspension. It was found that the depositions of alkaline SnO_2 suspension occurred on positively charges alumina substrate. Zeta potential analysis result shown in Figure 1 that clearly indicated that the zeta potential values of pH 7 to pH 11 suspensions are in negative values range. A negative value of zeta potential indicates that the SnO_2 particles suspended in pH7 to pH11 suspensions are negatively charged. Hence, the deposition of SnO_2 suspended in alkaline suspension occurred at positively charged substrate. The range of SnO_2 surface charge suspended in alkaline suspension as analysed by zeta potential analysis is -20 mV to -30 mV. As the pH values in alkaline suspension continue to increase, the zeta potential values (surface charge) were reduced until it starts to be constant at pH9 until pH11. On the other hand, positive values range of zeta potential was observed in acidic suspension of pH2 to pH 4.

The SnO_2 surface charges in acidic suspension in range of 5 mV to 45 mV were found to be higher than the alkaline suspension. However, the value of pH_{iep} is 4.3. pH_{iep} is known as *isoelectric point* correspond to the condition where the zeta potential of a particle surface is zero ($\xi=0$)[9] and should be avoided during EPD. Therefore, from zeta potential analysis, alkaline SnO_2 suspension was chosen as better medium to perform the EPD process.

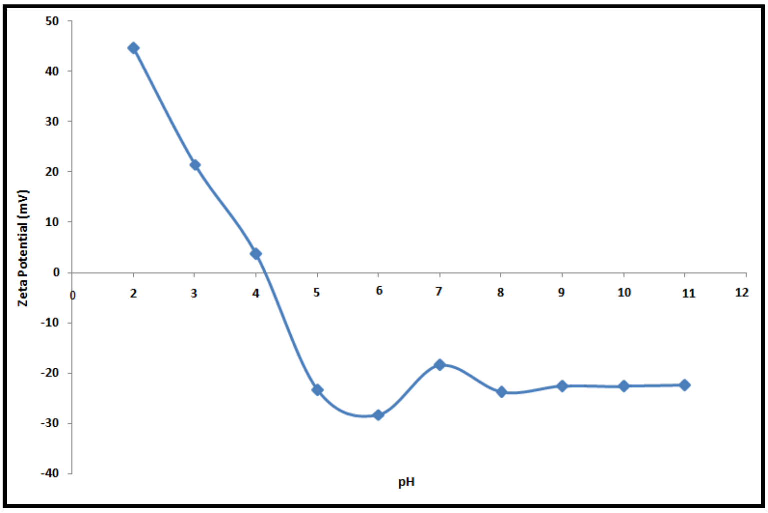
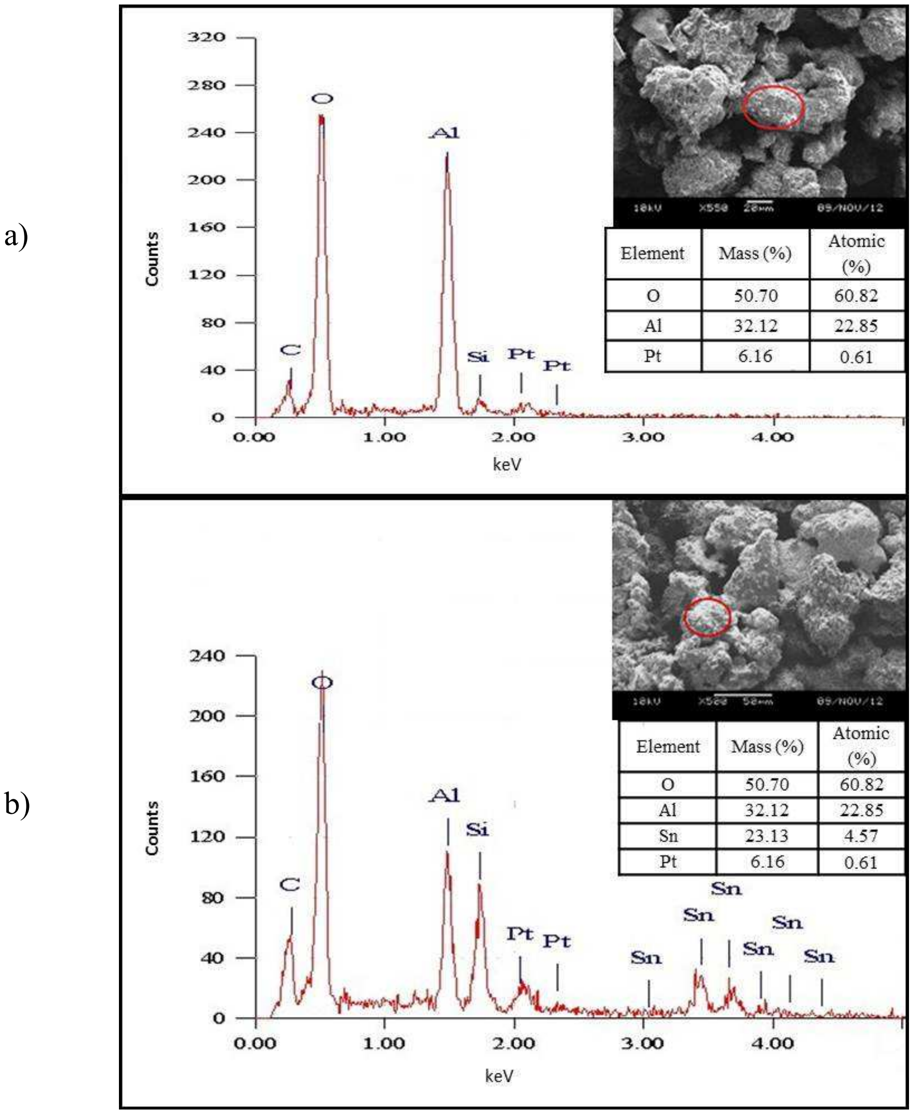


Fig. 1 : Typical plot of zeta potential as a function of pH for SnO_2 suspension.

Elemental analysis of SnO_2 deposited. *DS* analysis in Figure 2 (a) indicates the presence of elements Oxygen (O), Aluminium (Al), and Platinum (pt) on alumina substrate before SnO_2 depositions. Al was the raw material used to fabricate the porous alumina substrate, while Pt was the coating material used for EDS samples preparation. *EDS* analyses on alumina substrate after SnO_2 deposition is shown in Figure 2(b), in which the element of stanum (Sn) presence on alumina substrate is clearly shown, thus confirming successful the SnO_2 deposition on the alumina substrate.



Element	Mass (%)	Atomic (%)
O	50.70	60.82
Al	32.12	22.85
Pt	6.16	0.61

Element	Mass (%)	Atomic (%)
O	50.70	60.82
Al	32.12	22.85
Sn	23.13	4.57
Pt	6.16	0.61

Fig. 2 : (a) Representative EDS analysis on alumina substrate before SnO_2 coating (b) Representative the EDS analysis on alumina substrate after SnO_2 coating from SEM.

Weight of SnO_2 deposits on alumina substrate The percentage of weight changes of SnO_2 deposition in alkaline SnO_2 suspensions increases as amount of pH increase (Figure 3). However, when the pH of the SnO_2 suspension increased, zeta potential value is decreased and the deposition on the substrate is increased. High zeta potential values would lead to high stability and lower zeta potential values lead to lower stability suspension[9]. In EPD, a lower stability suspension (lower zeta potential value) is advantageous as movement of charged particles is not hindered by the suspension stability[10]. This condition agrees well with the finding from this study as lower zeta potential value produces higher depositions.

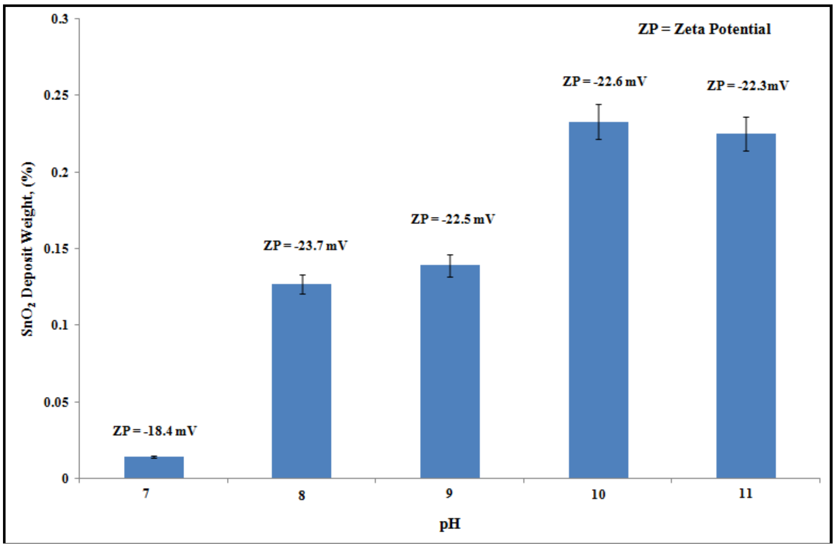


Fig. 3: The weight changes of SnO_2 deposition on alumina substrate with different pH

Conclusion

Overall, SnO_2 suspended in alkaline suspensions *i.e* negatively surface charged yielded good depositions of SnO_2. Morever, it was found that the SnO_2 deposit increases as the zeta potential values of SnO_2 decreases. Thus, it concluded that lower zeta potential values produce better SnO_2 deposition during EPD as lower zeta potential values leads to moderately stabilised SnO_2 suspension which could overcome the problem of charged SnO_2 particles movement hindrance during EPD.

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