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Comparitive study on self-cleaning property of Activated charcoal supported Bi_2O_3–ZnO with other coupled semiconductor oxide nanocomposites

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ABSTRACT

Development of active semiconductor oxide nanomaterials create a vital role in catalytic effective materials. Here we compare the self-cleaning property of Activated charcoal supported Bi_2O_3 – ZnO (AC − BZ) nanocomposites with other Photocatalytic nanocomposites of $CdWO_4$ −ZnO and Pr_6O_{11} − ZnO. This study has been evaluated using contact angle measurement and our results give some new vision on the performance of coupled semiconductor oxide nanomaterials on environmental basis.

Keywords— *Activated Charcoal supported Bi_2O_3–ZnO, $CdWO_4$–ZnO, Pr_6O_{11}–ZnO, Self-cleaning, Tetra ehtoxy ortho silane*

1. INTRODUCTION

Self-cleaning is one of the most important challenging applications in industrial engineering and it is proved by contact angle measurement. Water contact angle (WCA) shows the wettability of a solid surface by the liquid compound. Hydrophobicity is one of the important properties that provides water repellency and non-wettability of the solid surface. Especially some plants like lotus leaves exhibit this kind of property as an important part of self-cleaning mechanism. Normally heterostructure nanocomposites shows its good hydrophobicity. We tested the hydrophobicity of the different catalysts and how far it is better for environmental remediation.

2. EXPERIMENTAL SECTION

2.1 Catalyst Characterization for Water Contact Angle measurement

Spin coating method is fabricated on a glass substrate with catalysts and tetra ethoxy Ortho silane (TEOS). The water contact angles were measured using a Drop Shape Analyzer (DSA) (Kruss GmbH, Germany).

2.2 Water Contact Angle measurement for $CdWO_4$ − ZnO

The volume of water droplet was approximately 4 ml and five measurements were taken. The average of these values is taken as Water Contact Angle (WCA) on the substrate. Catalysts coated substances were heated at 125° C for 2 hours with rating of 5° C /min in a programmed furnace to ensure densification of the gel network.

2.3 Water Contact Angle measurement for Pr_6O_{11} – ZnO

Catalysts coated substrates were heated at 125° C for 3 hours with rating of 5°C/min in a programmed furnace to ensure densification of the gel network.4 ml water droplet was placed on the coating and its water contact angle was measured. The average of 5 measurements is reported as the water contact angle (WCA) on the substrate.

2.4 Water Contact Angle measurement for Activated charcoal supported Bi_2O_3 –ZnO (AC– BZ)

Approximately 4 ml of water droplet was taken for the analysis and at least five measurements were taken. Average of these values is considered as water contact (WCA) on the substrate. AC-BZ modified silane coatings were successfully fabricated on a glass plate using spin coating method at room temperature. AC-BZ nanocomposite coated substrates were sintered at 125° C for 3 hours with rating of 5° C /min in a programmed furnace to ensure densification of the gel network.

3. RESULTS AND DISCUSSSION

3.1 Water Contact Angle measurement for $CdWO_4$ – ZnO nanocomposites

Surface non-wettability of prepared catalyst is revealed by the water contact angle. If a surface has a contact angle with water that is above 90°, then the surface is classed as hydrophobic and if the contact angle is below 90° the surface is hydrophilic. Water contact angles were determined on glass slides coated with Tetra Ethoxy Ortho Silane (TEOS), TEOS + ZnO and TEOS + $CdWO_4$ – ZnO to study the hydrophobicity or surface non-wettability of the catalysts. Figure 1 shows the images of water drops on coated and uncoated glass slides. Water contact angle (WCA) of 29°on coated glass slide shows the hydrophilicity and this WCA increases gradually on glass slides coated with TEOS (50°), TEOS + ZnO (73°) and TEOS + $CdWO_4$ – ZnO (91.9°). Hydrophobicity attains a maximum value of 91.9° with TEOS + $CdWO_4$ – ZnO coated glass slides. The above results obviously show that the surface coated with $CdWO_4$ – ZnO has larger hydrophobic character leading to increase in surface non-wettability. This lotus effect caused by increased surface non-wettability, leads to a self-cleaning property of the catalyst.

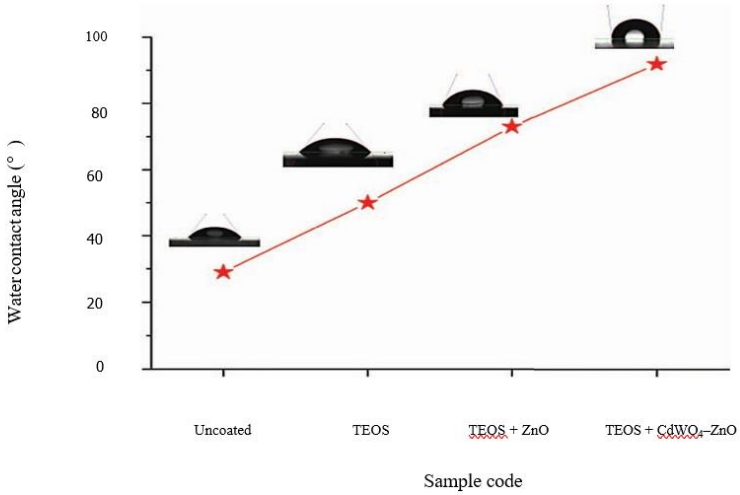

Fig. 1: Contact angle (a) uncoated, (b) TEOS, (c) TEOS + ZnO, (d) TEOS + $CdWO_4$ – ZnO

3.2 Water Contact Angle measurement for Pr_6O_{11} – ZnO nanocomposites

Surface non-wettability of catalyst was evaluated using the water contact angle meter. If a surface has a contact angle with water that is greater than 90° then the surface is classed as hydrophobic, and if the contact angle is less than 90°, the surface is hydrophilic. Water contact angles were measured on glass slides coated with TEOS, TEOS + ZnO, TEOS + Pr_6O_{11}, and TEOS + Pr_6O_{11} – ZnO to study the hydrophobicity or surface non-wettability of the catalysts. Figure 2 shows the images of water drops on coated and uncoated glass slides. Water contact angle of 39.7° on uncoated glass slide shows the hydrophilicity. Water contact angle increases gradually on glass slides coated with TEOS (50°), TEOS + Pr_6O_{11} (62.8°), TEOS+ ZnO (70.5°), and TEOS + Pr_6O_{11} – ZnO (101.1°). Hydrophobicity increases and reaches a maximum value of 101.1° with TEOS + Pr_6O_{11} – ZnO coated glass slides. This shows that the surface coated with TEOS + Pr_6O_{11} – ZnO has more hydrophobic character leading to an increase in surface non-wettability. This lotus effect caused by increased surface non-wettability leads to a self-cleaning property of the catalyst.

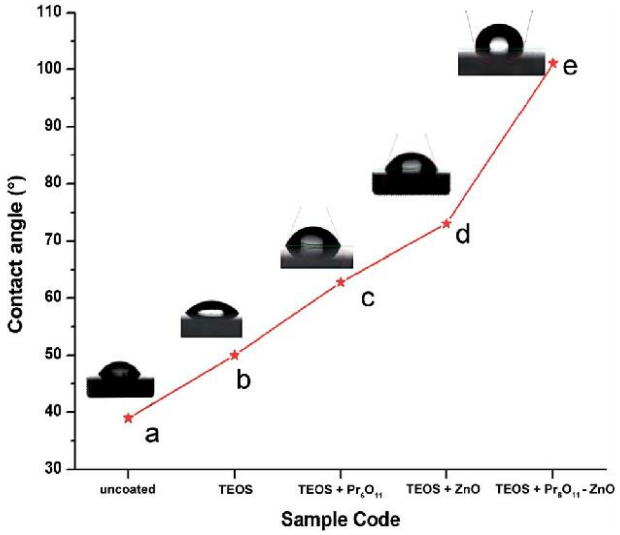

Fig. 2: Contact angle (a) uncoated, (b) TEOS, (c) TEOS + ZnO, (d) TEOS + Pr_6O_{11}, and (e) TEOS + Pr_6O_{11} – ZnO.

3.3 Water Contact Angle measurement for Activated charcoal supported Bi_2O_3 –ZnO (AC– BZ) nanocomposites

Surface non-wettability or the hydrophobicity of the catalyst is revealed by water contact angle. If a surface has a contact angle with water that is greater than 90°, then the surface is classed as hydrophobic and if the contact angle is less than 90°, the surface is hydrophilic. Water contact angles were measured on glass slides coated with TEOS + ZnO and TEOS + AC – BZ to analyze the hydrophobicity of the catalysts. Fig. 3 shows the images of water drops on coated and uncoated glass slides. Water Contact Angle (WCA) of 22.5° on uncoated glass slide (a) shows the hydrophilicity and this WCA increases gradually on glass slides coated with TEOS (49.5°), TEOS + ZnO (74.4°) and TEOS + AC – BZ (106.3°).This shows that the surface coated with TEOS +AC – BZ has

greater hydrophobic character. This hydrophobicity increases the surface non-wettability, leading to a self-cleaning property of the catalyst.

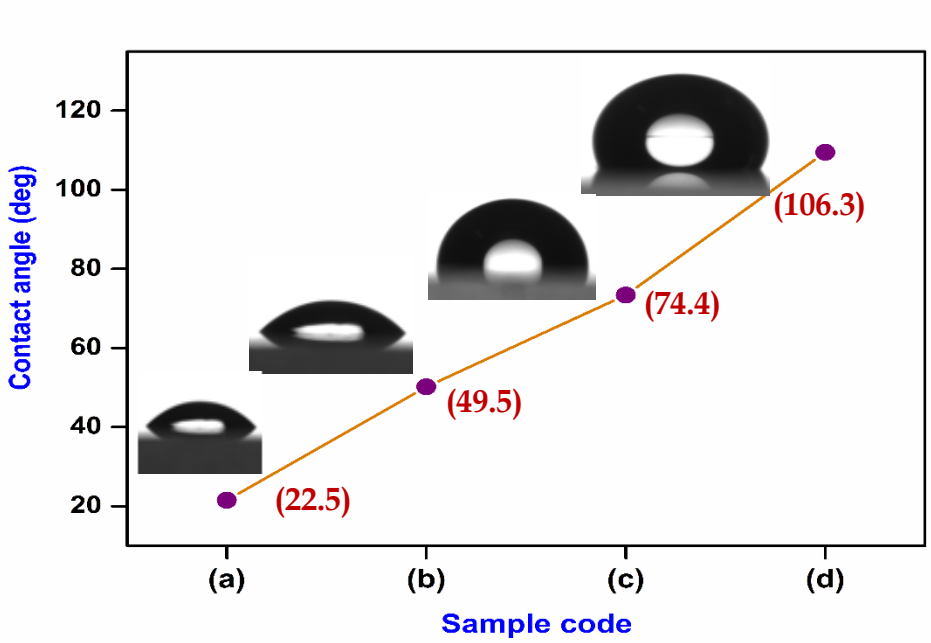

Fig. 3: Water contact angle measurements (a) uncoated glass slide, (b) TEOS coated glass slide, (c) TEOS+ZnO coated glass slide and (d) TEOS+ AC-Bi_2O_3-ZnO coated glass slide.

4. COMPARITIVE STUDY OF SELF-CLEANING PROPERTY OF SEMICONDUCTOR OXIDE NANOCOMPOSITES

The Surface non-wettability of the catalyst is revealed by water contact angle. The hydrophobicity increases and reaches a maximum value of 91.9° with TEOS + Cadmium tungstate –Zinc oxide, 101.1° with TEOS + Praseodymium oxide – Zinc oxide and 106.3° with TEOS + Activated charcoal supported Bismuth oxide –Zinc oxide.

Table-1: Water contact angle of nanocomposites

S.NO	NANOCOMPOSITES	WCA
1	$CdWO_4$ – ZnO	91.9°
2	Pr_6O_{11} – ZnO	101.1°
3	AC – Bi_2O_3 –ZnO	106.3°

The above study shows that the surface coated with TEOS + AC – BZ has more hydrophobic character. In TEOS, the OH groups get replaced by stable O – Si – O groups and these groups are modified by AC – BZ to make the surface rougher, stable and non wet-able. That is why the contact angle increases above 90, exhibiting the hydrophobicity of the catalyst. This hydrophobicity increases the surface non-wettability, leading to a self-cleaning property of the catalyst.

5. CONCLUSION

The comparative study on self-cleaning property was made with following coupled semiconductor oxide nanocomposites namely $CdWO_4$ – ZnO, Pr_6O_{11} – ZnO and AC – Bi_2O_3 –ZnO. Out of three nano-composites, higher hydrophobicity (106.3°) of AC – BZ reveals its usefulness for industrial application as self-cleaning material. This increase in hydrophobicity of AC – BZ (106.3°) shows the better lotus effect for self-cleaning applications. Activated charcoal supported Bi_2O_3 –ZnO exhibits better self-cleaning applications.

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