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Comparative evaluation of Fe and Cu doped TiO_2 photocatalyst under visible light

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INTRODUCTION & AIM

Antifog, antireflective, antiglare and antibacterial coatings are some types of optical coatings applied to the surface of glassy pieces and other devices to improve their performances. TiO_2 is the most famous antifog agent due to its highly hydrophilic behavior under ultra violet (UV) light. The photocatalytic glass performs better in several applications such as in buildings, food packing, medical laboratories, etc. This property has been developed by applying TiO_2 photocatalyst on the surface of glass to enhance the photocatalytic effect in the UV region. However, the need for a UV source limits its benefits. To deal with this problem, a generic way is to modify TiO_2 by doping with a metal ions which lead to a decrease in band gap energy. therefore, photo excitation could occur as well in visible. The most popular dopants for this purpose are Ag, Fe, Cu, Au, Pt, etc., which have been doped by many production methods [1].

METHOD

In this study, undoped and Cu and Fe-doped TiO_2 thin films with different weight percentages (0.8 - 3) were synthesized by the sol-gel dip-coating method. This synthesis procedure is illustrated in Fig. 1.

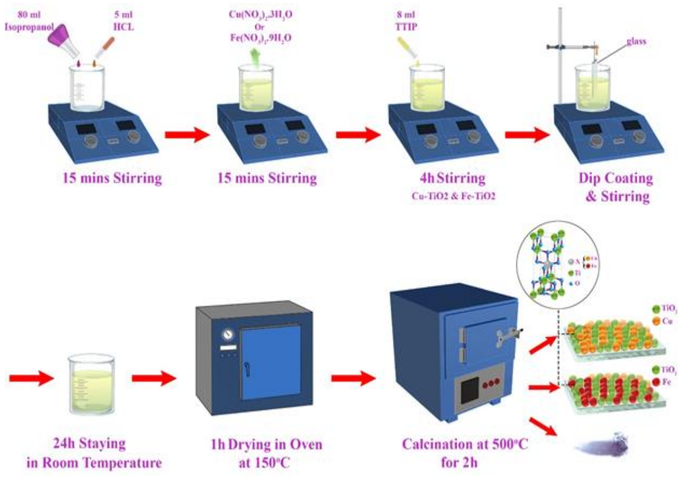

Fig 1. Schematic procedure for the synthesis.

The samples were characterized by X-ray diffraction (XRD), field emission scanning electron microscopy (FE-SEM), ultraviolet and visible spectroscopy (UV–Vis) and the Brunauer-Emmett-Teller (BET) analysis to study their structure, morphology, porosity and optical properties. Degradation of a organic dye, water contact angle and antibacterial tests were carried out for photocatalyst evaluation.

RESULTS & DISCUSSION

Table 1. Structural properties of thin films of TiO_2 and TiO_2 doped with Cu and Fe.

Sample	D × 10^{-9} m	δ × 10^{14} lines/m^2	Band Gap (eV)	BET/m^2 g^{-1}
Undoped TiO_2	37.45	7.13	3.20	2.0
0.8Cu–TiO_2	11.98	69.67	2.40	58.2
1.5Cu–TiO_2	17.72	31.84	2.70	43.6
2.2Cu–TiO_2	22.42	19.89	2.78	37.5
3Cu–TiO_2	27.55	13.17	3.00	30.4
0.8Fe–TiO_2	30.28	10.90	3.18	27.9
1.5Fe–TiO_2	26.56	14.17	3.00	33.3
2.2Fe–TiO_2	23.5	18.10	2.82	34.9
3Fe–TiO_2	18.9	27.99	2.65	45.2

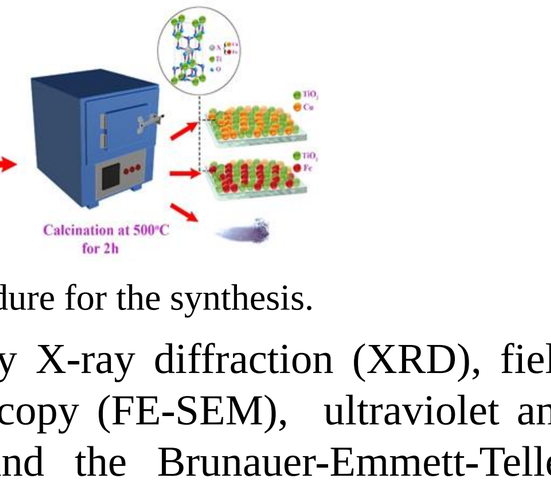

Fig. 2

Results from XRD analyses, band gaps and BET surface areas are illustrated in Table 1, which match the better activities shown with the doped samples, specially 0.8Cu-doped and 3Fe-doped TiO_2, both for dye degradation (Fig. 2) and hydrophilicity under visible light irradiation, as it illustrated in Fig. 3.

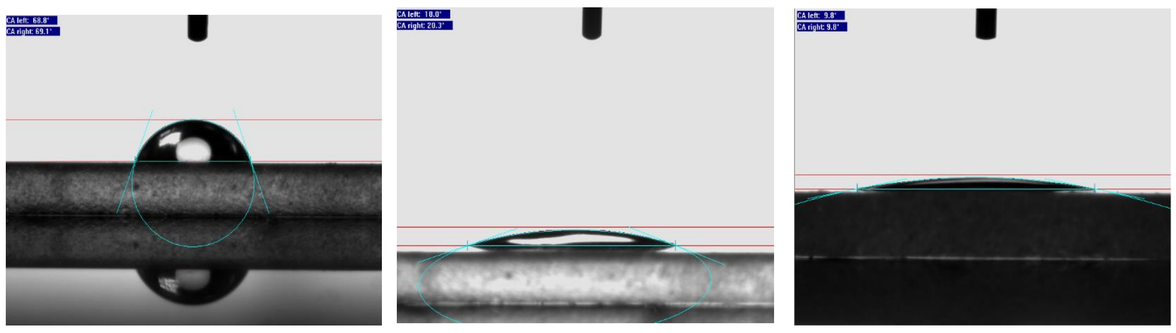

Fig 3. A typical shape of 5 μl of water droplet over pure TiO_2, 3Fe and 0.8Cu-doped TiO_2 thin films.

Furthermore, antibacterial assays under visible light showed that the best doping levels for enhanced photocatalytic and antibacterial performance were identified as 0.8Cu and 3Fe, respectively as shown in Fig. 4. The most widely accepted mechanism of ROS attack on (E. Coli) is depicted in Fig. 5 [2][3].

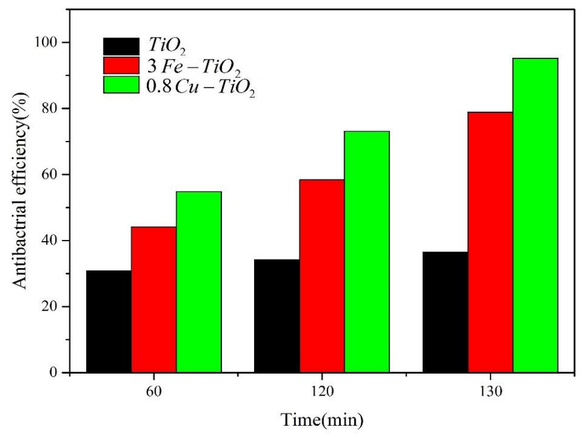

Fig. 4 The percentage reduction in E. Coli colonies for pure TiO_2, 0.8Cu/TiO_2, and 3Fe/TiO_2 following irradiation for 1, 2, and 3 hours.

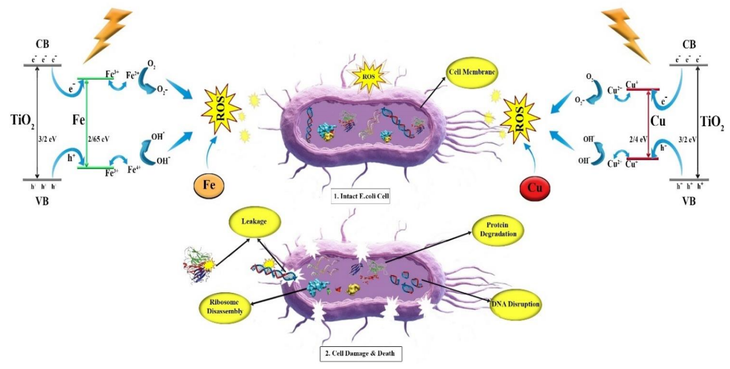

Fig.5 Mechanisms of E.Coli elimination. On the left and right side of the figure, the activation of Fe/TiO_2 and Cu/TiO_2 by visible light is illustrated.

CONCLUSION

Transparent TiO_2 and doped TiO_2 films were successfully prepared to enhance the self-cleaning and antibacterial properties of glass. Increasing the dopant concentration modified the semiconductor band gap, thereby improving the film's photocatalytic activity. Among all the doped films, 0.8Cu/TiO_2 sample exhibited the highest photocatalytic activity and hydrophilicity under visible light. However, for pure TiO_2 photocatalysts, the degradation efficiency did not significantly change with irradiation time, which can be attributed to the limited absorption of visible light by undoped TiO_2.

FUTURE WORK / REFERENCES

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