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Sol-gel preparation of pure and doped TiO_2 films for the photocatalytic oxidation of ethanol in air

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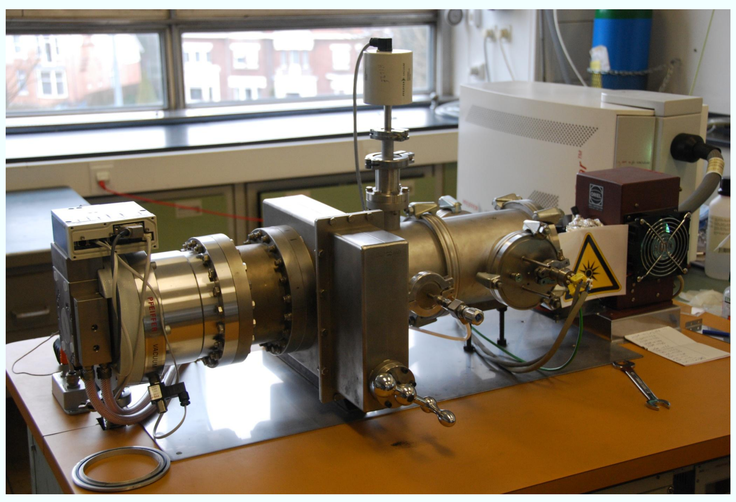
Introduction

Photocatalysis : removal of small amounts of VOCs from contaminated indoor atmosphere.

TiO_2 is close to being an ideal photocatalyst: non toxic, physico-chemically stable, self-cleaning and highly selective.

Sol-gel method is one of the most versatile methods to obtain TiO_2: control of stoichiometry, synthesis in mild and ambient atmospheric conditions, high purity, porosity and homogeneity.

Aim of this study: synthesize stable TiO_2 sols by the sol-gel method, preparation of thin films, evaluate the influence of a stabilizing agent (diethylene glycol) and the effect of V, Nb and Ta doping on the photocatalytic activity of the films.



Choice of the best film preparation conditions:

- Number of layers (single, double and triple coating)
- Pre-heat treatment at 100 °C for 8h
- Different calcination temperature (450, 500 or 550 °C)

Sample	Number of layers	Pre-heat treatment at 100°C	Calcination temperature (°C)	Photocatalytic activity ± 3σ (ppm/min)
A	1	yes	450	3.09±0.23
B	2	yes	450	3.24±0.28
C	3	yes	450	1.76±0.15
D	1	no	450	1.87±0.30
E	2	yes	500	0.60±0.05
F	2	yes	550	0.49±0.06
P25	4	—	—	3.64±0.03

Photocatalytic measurements: carried out in a stainless steel batch reactor, in a controlled Ar/O_2 atmosphere, by means of an atmospheric gas analyser containing a mass spectrometer.

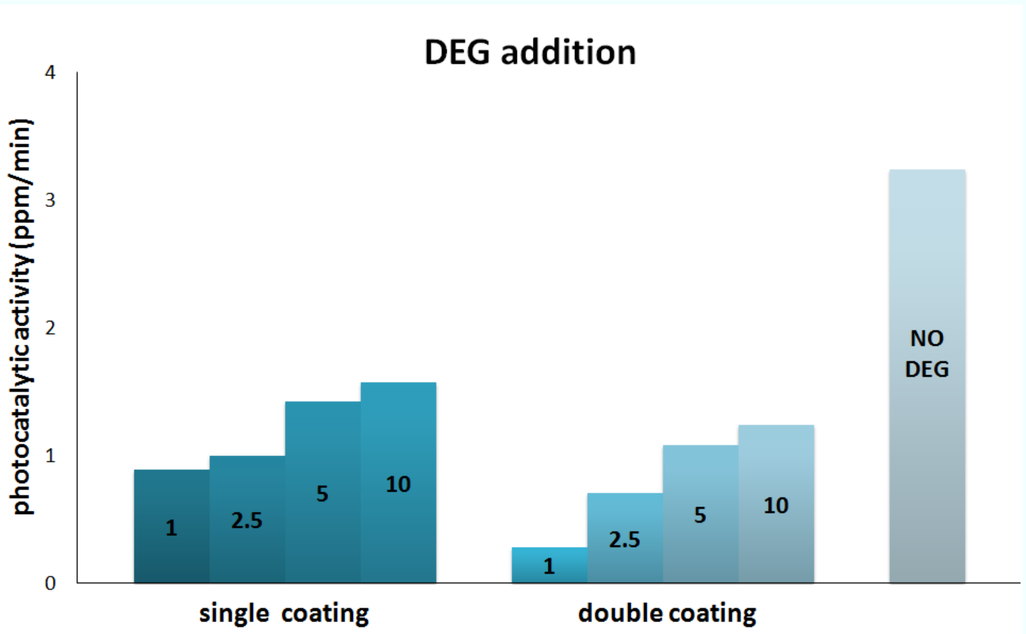
Double coated film, pre-heated at 100°C for 8h and calcined at 450 °C for 2h: highly active if compared with TiO_2 films prepared from Degussa P25.

Stabilizer effect

Addition of DEG: stabilization of the sol and improvement of the adhesion film/glass [1].

DEG experiments performed:

- Different amounts of additive (molar ratios 1, 2.5, 5 and 10)
- Number of layers (single and double coating)

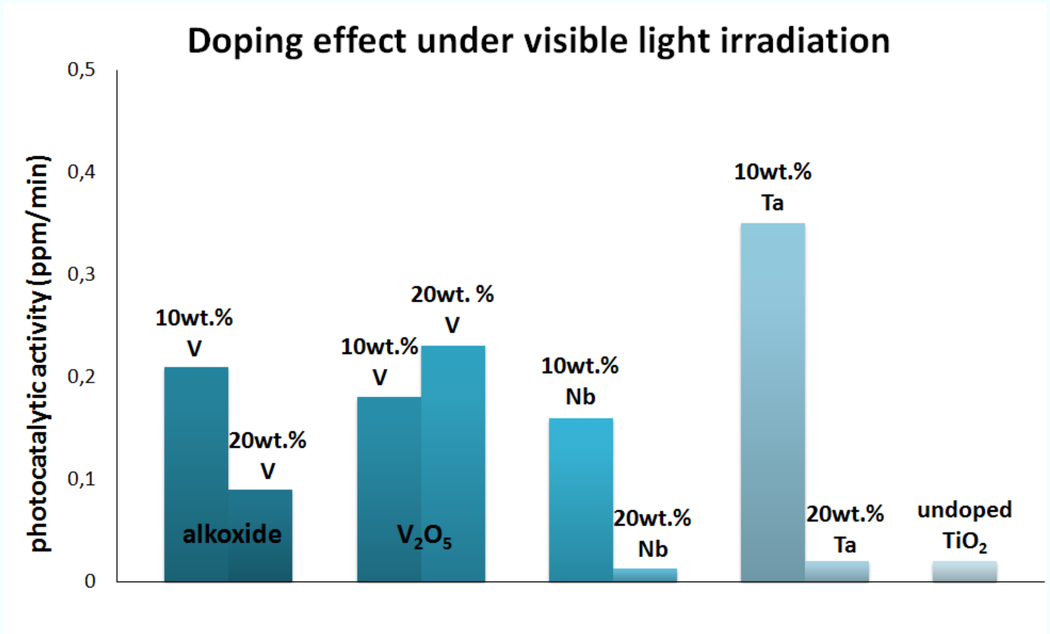


Doping effect

Aim: obtain a higher photoresponse in the visible region.

Experiments: series of 10 and 20wt.% vanadium, niobium and tantalum-doped TiO_2 catalysts .

Precursor used: dopant alkoxide; for V doping two different precursors: alkoxide and V_2O_5 .



Conclusions

- DEG addition does not improve the photocatalytic activity of the films.
- The visible response is larger for the 10wt.% doped film than for the 20wt.% one, in case the alkoxide is used as dopant precursor.
- The doping process was successful and the dopants were inserted into the TiO_2 unit cell as confirmed by XRD analysis.
- Among the developed catalyst, the 10 wt.% Ta doped titania shows the highest photocatalytic activity and this is attributed to a similar ionic radius between Ta and Ti.

References

[1] H. Tomaszewski et al., Int. J. Photoenergy 8 (2007) 1-5

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