Preparation of ZnO-TiO₂ Composite Materials and their Photocatalytic Activity for the Degradation of Acetaldehyde

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Introduction

- Both zinc oxide (ZnO) and titanium dioxide (TiO₂) are excellent photocatalysts on their own, with similar properties.
- ZnO-TiO₂ composite materials with a wide variety of compositions are prepared to study whether the photocatalytic activity of ZnO and TiO₂ could be improved by combining them into a composite material.

Methods

- Synthesis of the composite materials was achieved using a facile sol-gel-approach.
- The photocatalytic activity was determined by acetaldehyde degradation in a steady state gas-phase reaction.
- Measurement conditions: Gas flow rate: 1.0 L·s⁻¹; acetaldehyde concentration: 1.0 ppm; UVA-light intensity (λₘₚₙₐₓ=367 nm): 2.5 W·m⁻²; irradiation area: 3.9·10⁻³ m²; reactor volume: 25 mL; residence time: 1.49 s; relative humidity: 50 %.
- The Photocatalytic activity is expressed as the dimensionless photonic efficiency ξ:

\[ ξ = \frac{\text{Reaction rate}}{\text{Incident photon flux}} \]

Results

- No increase in activity could be observed for samples with medium (1-99 %) concentrations of zinc (Figure A).
- Very low zinc concentrations seem to enhance the activity of TiO₂ up to a photonic efficiency of 0.35 % (at 0.01 % Zn) (Figure B).
- By adding small amounts of Titanium to ZnO, the photonic efficiency could be increased to a maximum of 1.45 % (at 99.998 % Zn) (Figure C).

Conclusions

- ZnO-TiO₂ composite materials with different compositions could be synthesized in a facile way using sol-gel techniques.
- Samples with medium concentrations of zinc (1-99 %) did not show any significant increase in activity. In most cases, the activity even decreased.
- Improved activity of could be observed in samples with either very low or very high zinc concentrations (<1 % or >99 %).
- The optimal concentration for Zn in TiO₂ was 0.01 % (51 % increase in activity compared to pure TiO₂). The optimal concentration of Ti in ZnO was 0.002 % (160 % increase in activity compared to pure ZnO).

SEM-Analysis

- SEM-Pictures of samples containing a) pure TiO₂ (15-20 nm), b) ZnO/TiO₂ composite with 50% Zn (50-60 nm), c) pure ZnO (20-100 nm, inhomogenous).

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