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ZnO nanowires-on-quartz for efficient water purification

The issue of volatile organic compounds (VOCs) degradation using solar energy

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Introduction

The photocatalysis is proved to be the most efficient way for the degradation process of organic pollutants. ZnO and TiO₂ are supposed to be the most common photocatalysts due to their high performance in degradation by producing the oxidative free radical after being illuminated by UV light. Taking the advantages of these chemical properties, the environmental applications were developed by many research groups using micro-nano technologies. Furthermore, ZnO has biocompatibility advantage, and easy to obtain the high aspect ratio nanowires (NWs) via low-cost synthesis method with the further advantage of being firmly anchored to the substrate, leading to more sustainable applications.

Photocatalysis principle

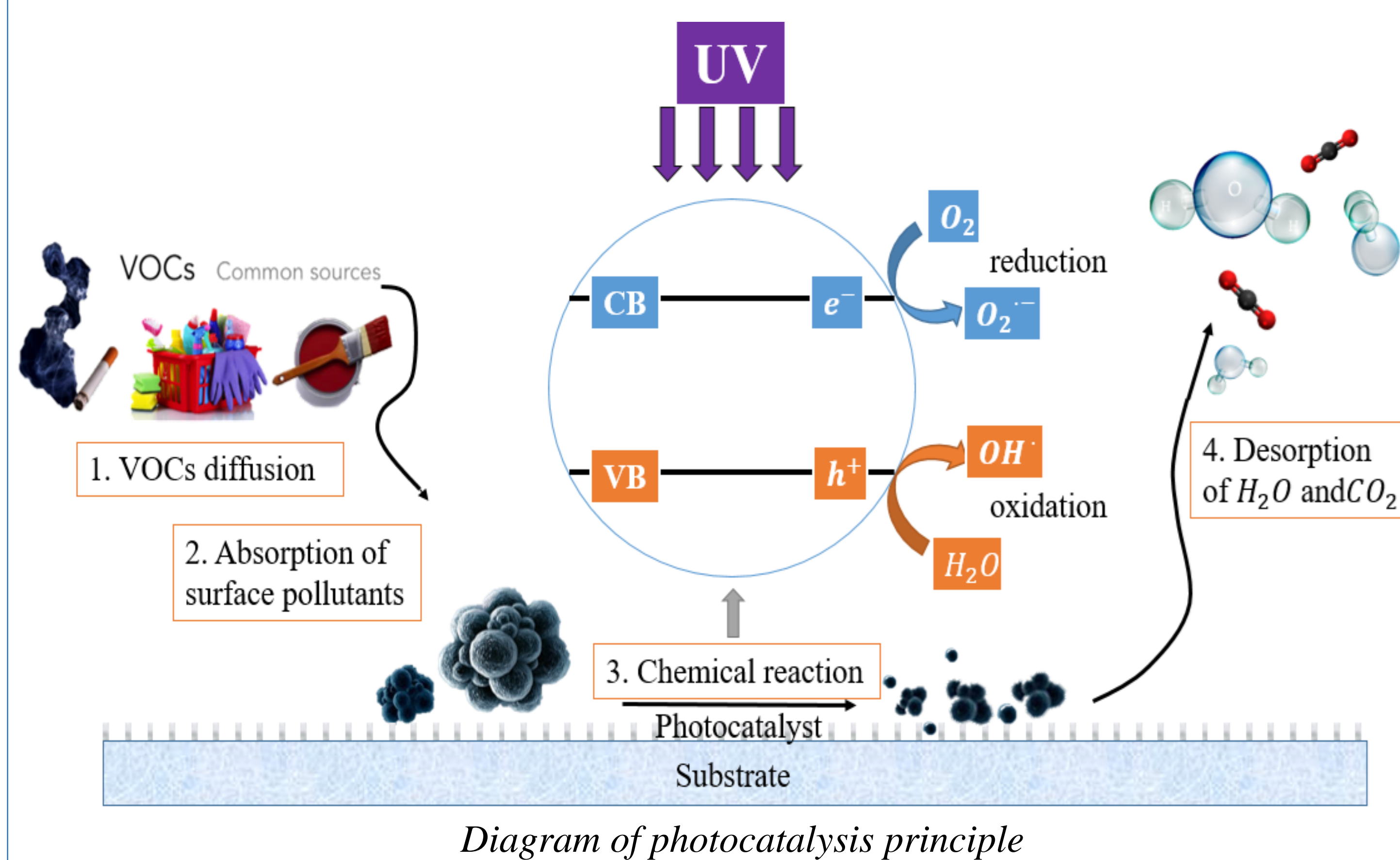
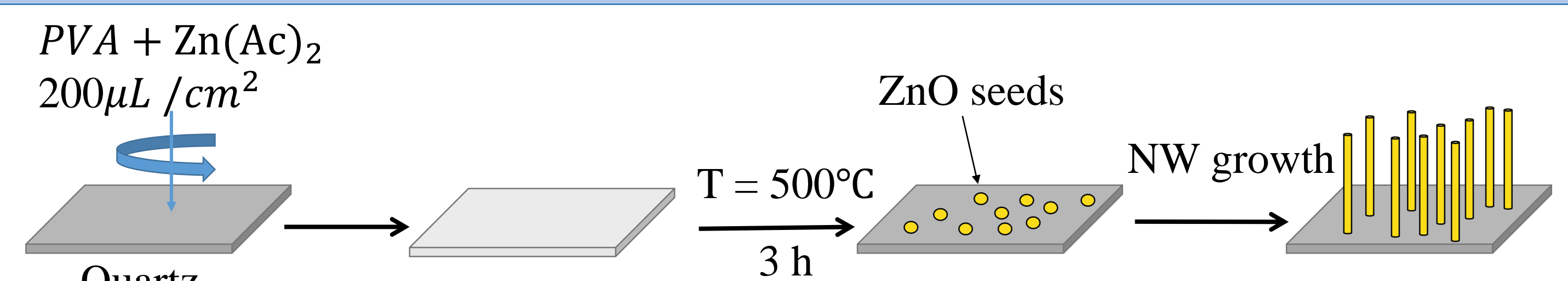


Diagram of photocatalysis principle

Synthesis of ZnO NWs



Two steps hydrothermal synthesis diagram

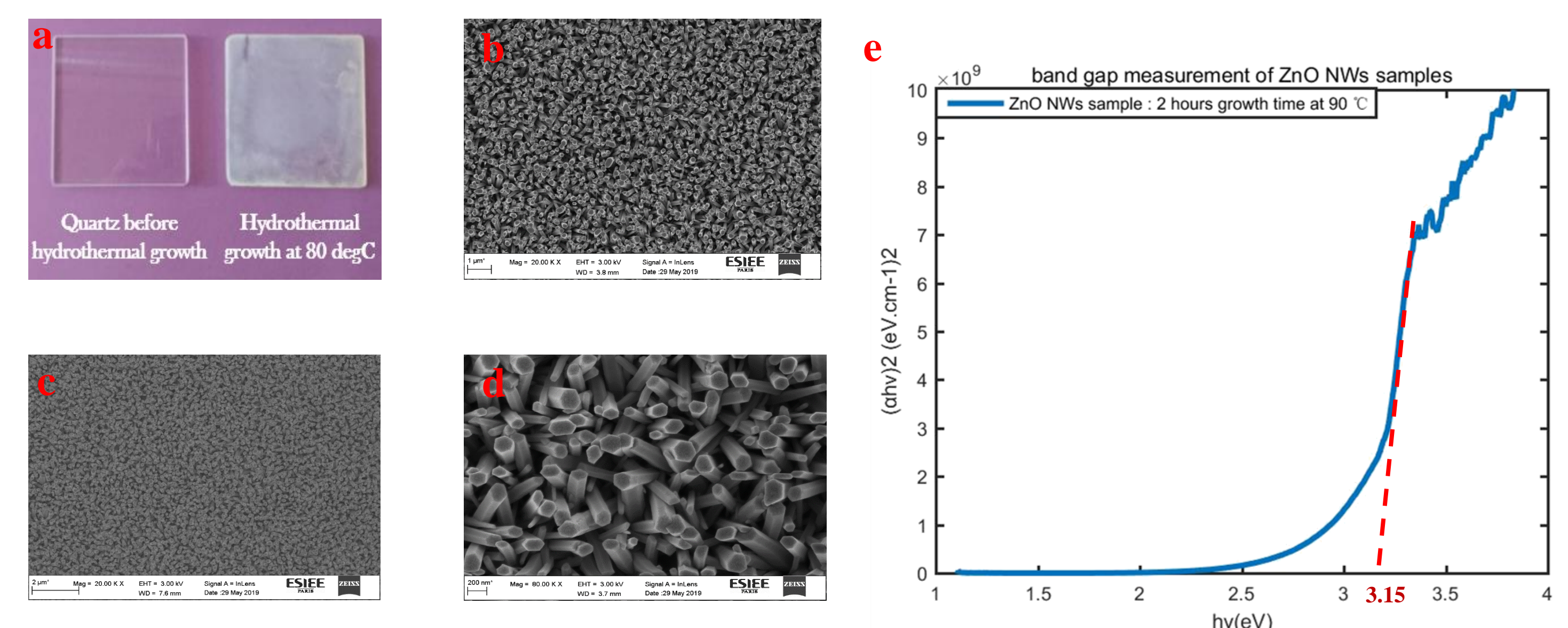
(1) Seedlayer deposition (At room temperature via spin-coating)

PVA + Zn(Ac)₂ 200 μL / cm²

(2) ZnO nanowires growth (At 90 °C for 2 hours)

25 mM Zn(NO₃)₂ + 12.5 mM HMTA

Characterization of ZnO NWs



(a) Quartz substrate & sample photos. (b) (c) (d) SEM pictures of ZnO NWs indicating homogeneous growth. (e) ZnO NWs band gap measurement.

Degradation of toluene

The polluted water sample was prepared with toluene (volatile organic compounds) with the concentration of 530 ppm. The macro water film flow was controlled with a given flow rate, which sited above the ZnO NWs on the quartz surface.

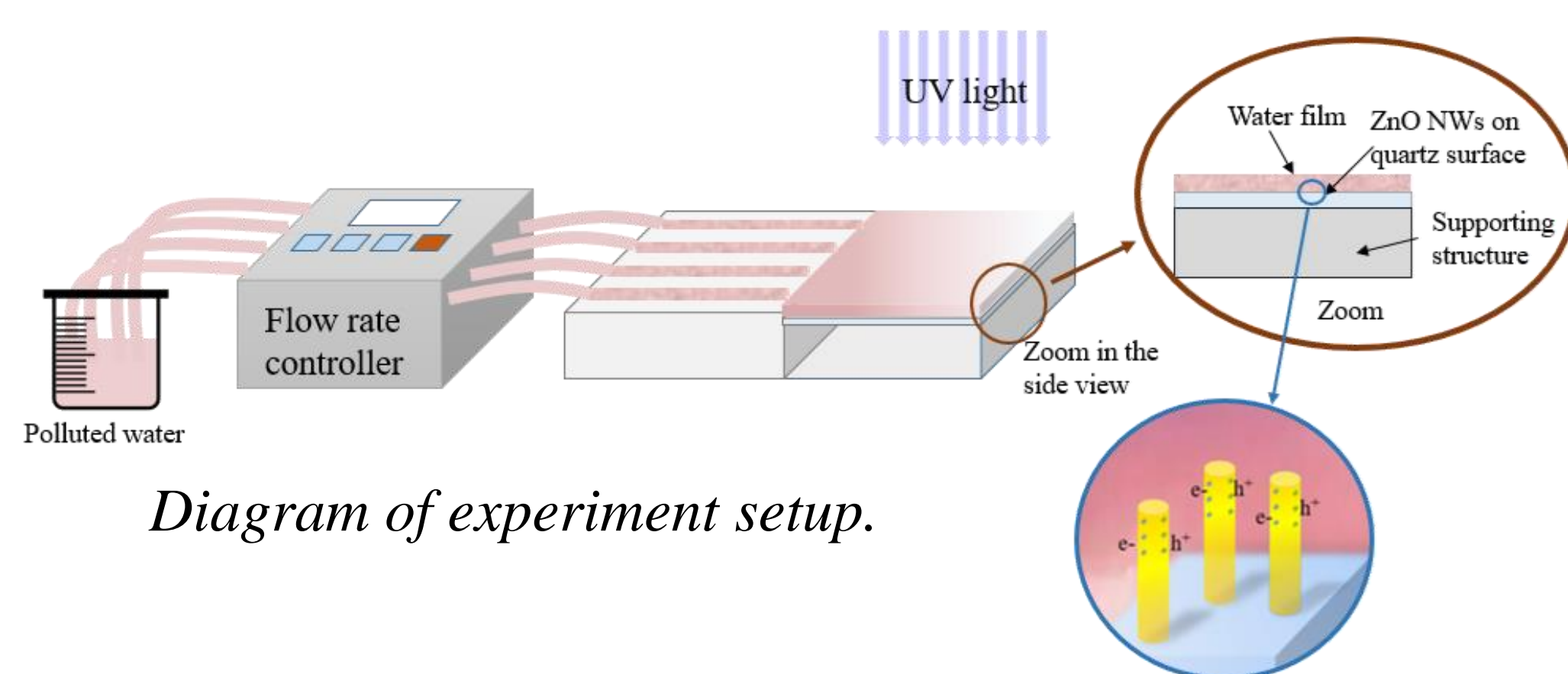
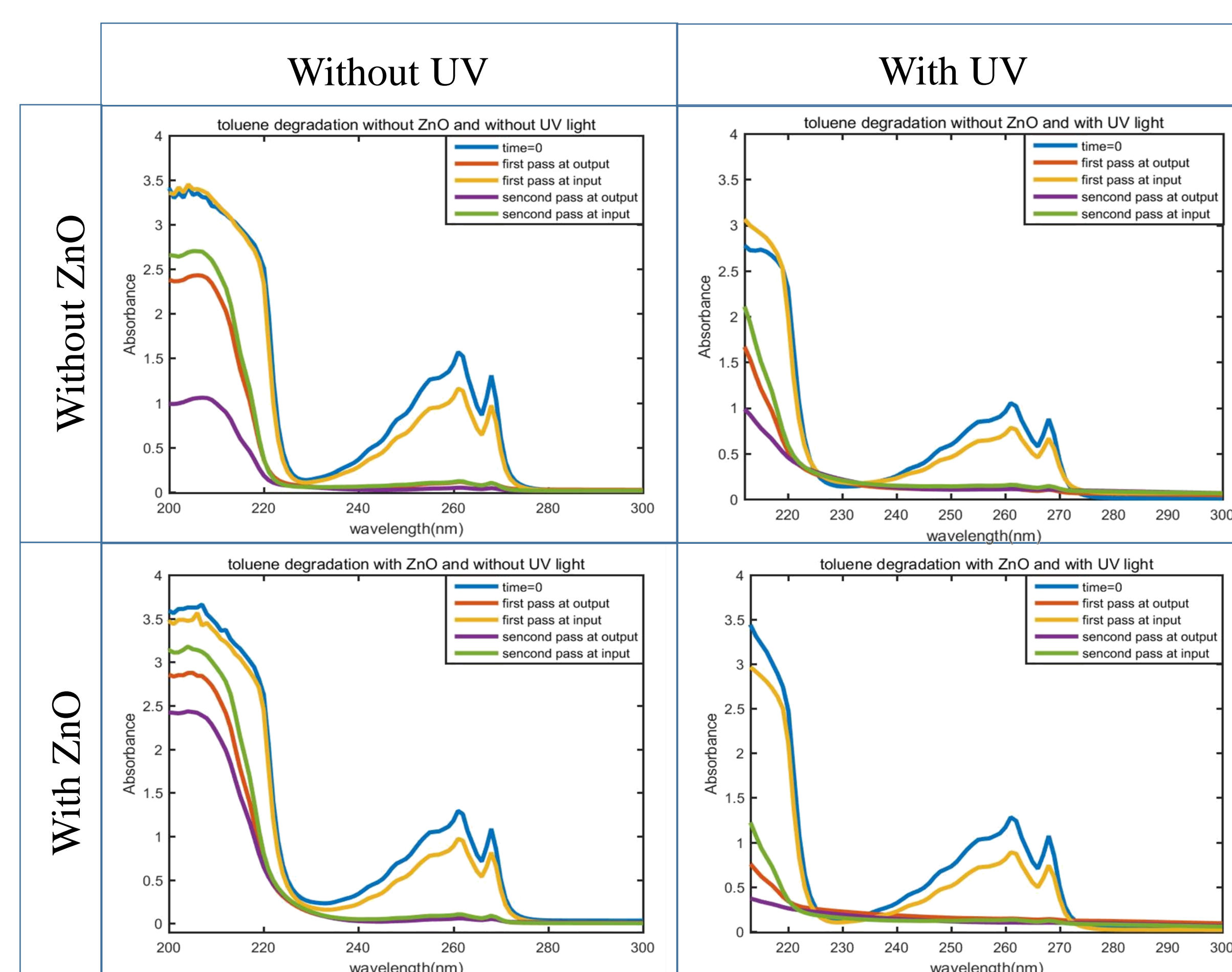
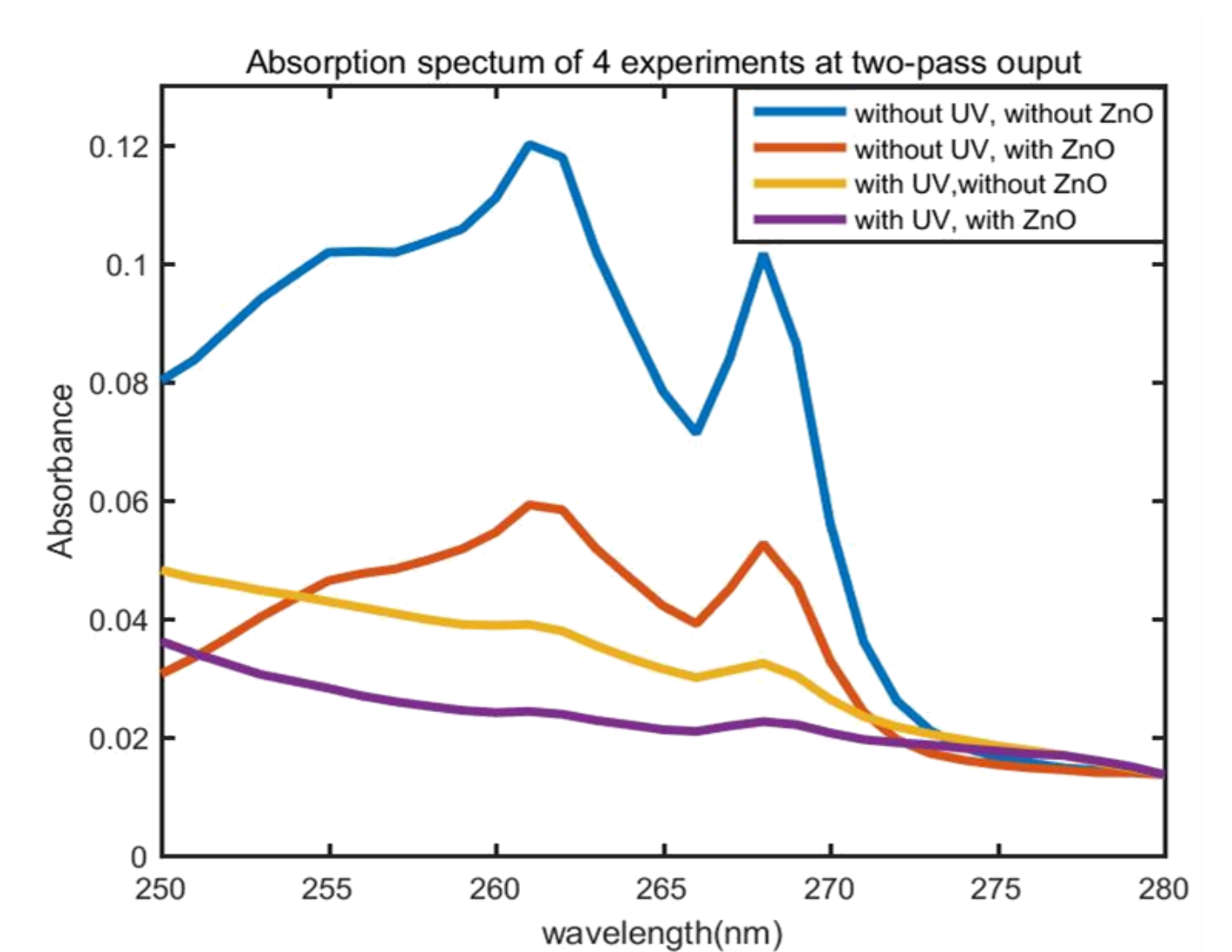


Diagram of experiment setup.

Using UV-Vis spectrum approach, the degradation effect can be obviously observed according to absorbance from analyses results. Due to the chemical property of toluene, 3 controlled experiments were conducted to compare as a blank reference to indicate the impact of UV light and the surrounding atmosphere.



Degradation effect of toluene in different conditions.



Absorption spectrum of treated water sample after two-pass.

After the second pass, the absorption spectrum of the treated water sample showed that the best degradation effect of toluene in water was with UV light and ZnO NWs; while the UV light also has a significant effect on toluene degradation.

Conclusion

- A homogeneous ZnO NWs has been successfully grown on the quartz surface via SEM observation, with a band gap of ~ 3.15 eV.
- The best performance of toluene degradation in water can be observed under UV light with ZnO NWs. The blank comparison experiments offset the volatile effect, which illustrates a further verification of ZnO NWs degradation effect with UV light.