Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)

N-doping offering higher photodegradation performance of dissolved black carbon for organic pollutants: experimental and theoretical studies

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Cite this as: Yong GUO, Mengxia CHEN, Ting CHEN, Ying GUO, Zixuan XU, Guowei XU, Soukthakhane SINSONESACK, Keophoungeun KANMANY, 2024. N-doping offering higher photodegradation performance of dissolved black carbon for organic pollutants: experimental and theoretical studies. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 25(4):340-356. https://doi.org/10.1631/jzus.A2300081

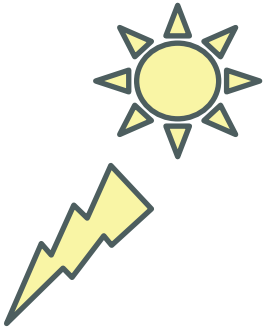
Dissolved Black Carbon in the Environment

Black Carbon's Resource

Nature

Human activities

Into water



h+

·OH

Dissolved Black Carbon (DBC)

$\cdot O_2^-$

$^1O_2$

$^3DBC^*$

Dyes

Antibiotics

photodegradation

small molecule+CO_2+H_2O

N-doped DBC in the Environment

Pyrolysis
Microwave
Hydrothermal

Urea

N-doped Biochar

Into water

Dyes

Antibiotics

N-doped DBC

h^+

$^1O_2$

$\cdot O_2^-$

$^3DBC^*$

$\cdot OH$

What's the effect of N-doping to the photodegradation of DBC for dyes and antibiotics?

Results and Discussion

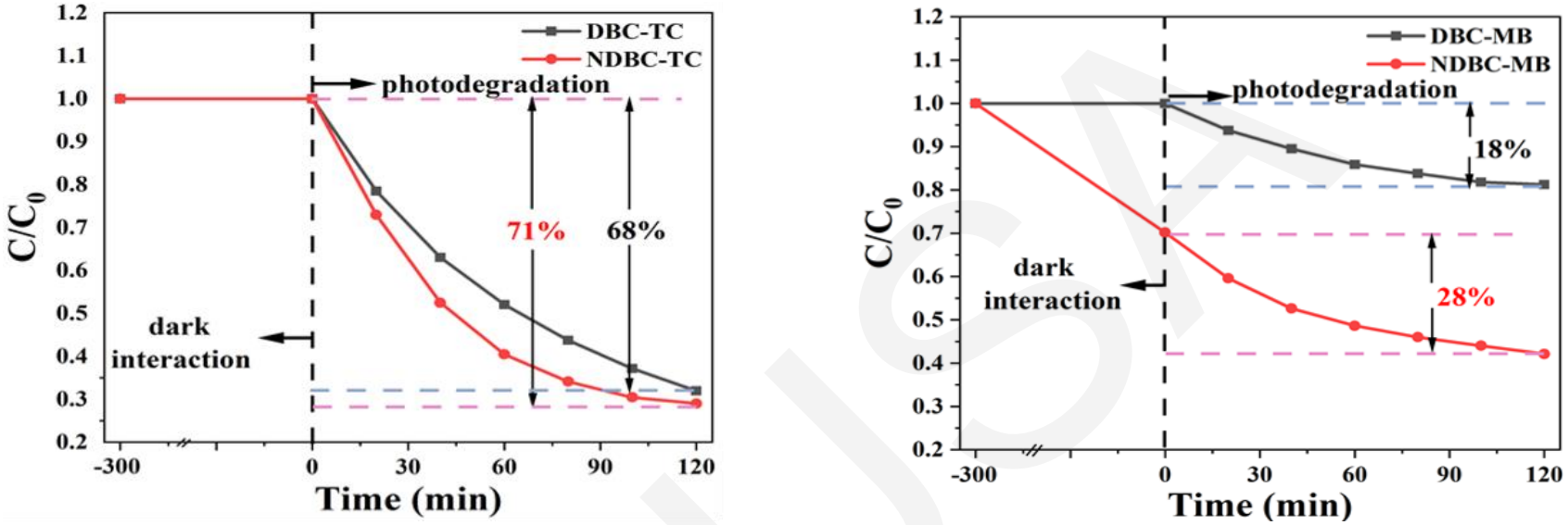


Fig. 1. Dark interaction and photodegradation performance of NDBC and DBC for TC; dark interaction and photodegradation performance of NDBC and DBC for MB.

The degradation performance of nitrogen-doped DBC (NDBC) for tetracycline (TC) (71%) is better than DBC for TC (68%).

The degradation performance of NDBC for Methylene (MB) (28%) is better than DBC for MB (18%).

In a word, N-doping offers higher photodegradation performance for DBC to TC or MB.

Results and Discussion

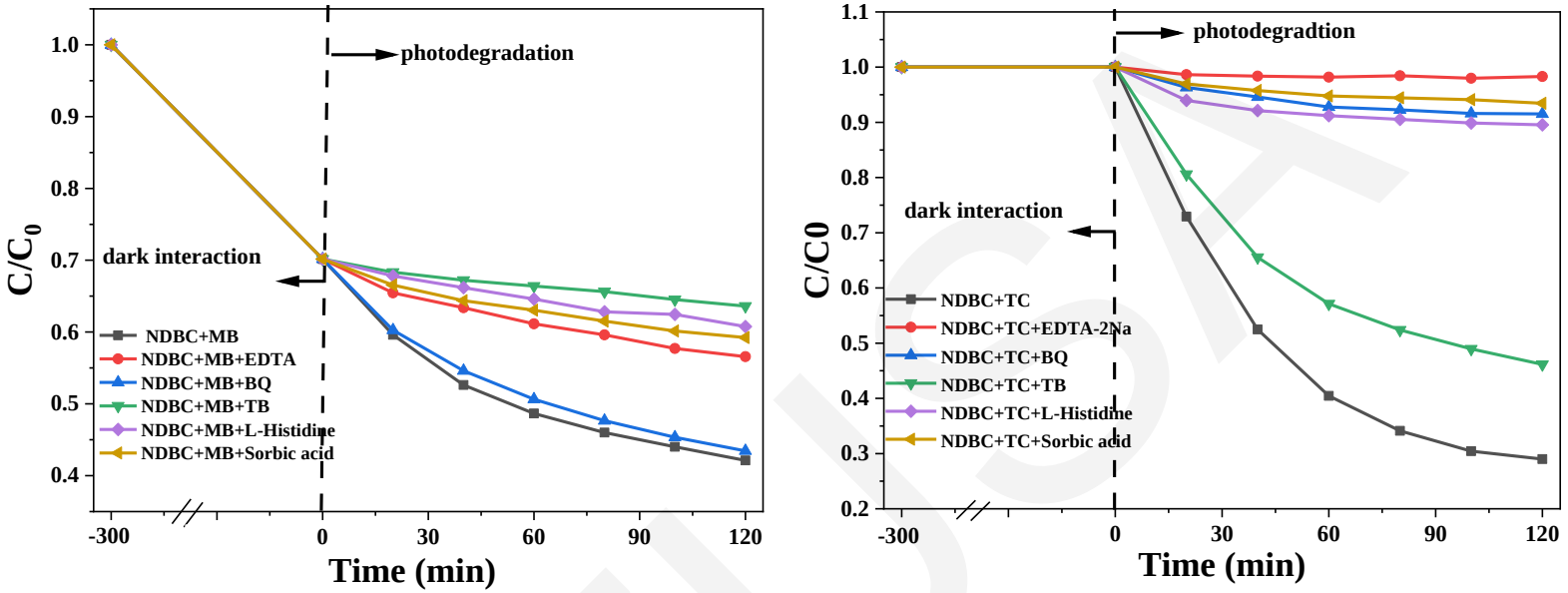
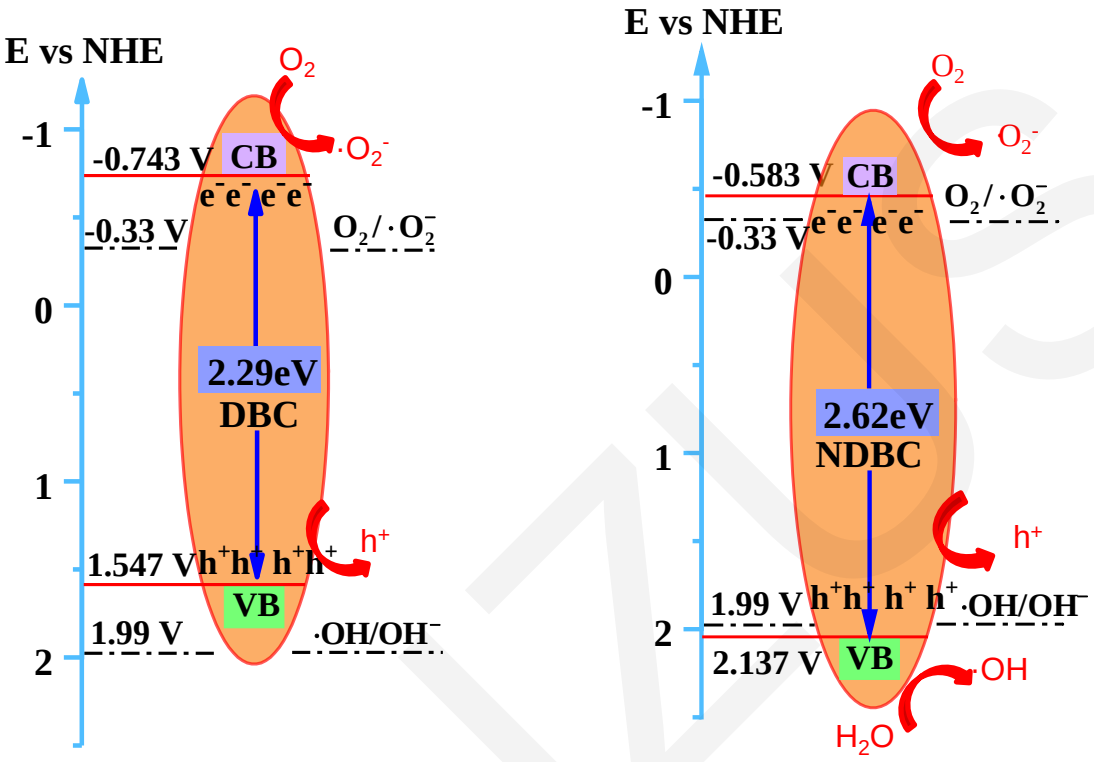


Fig. 2. Reactive species quenching experiments for TC photodegradation by NDBC; (b) reactive species quenching experiments for MB photodegradation by NDBC.

1. h^+, O_2-, $^1O_2$, and ^{3}NDBC* are the main photoactive species involved in TC photodegradation by NDBC. These findings are the same as those for TC photodegradation by DBC.
2. ·OH, $^1O_2$, ^{3}NDBC* and h^+ must be the main photoactive species during MB photodegradation by NDBC. During MB photodegradation by DBC, O_2-, $^1O_2$, and ^{3}DBC* were involved, while ·OH was not found.

Results and Discussion

■ Band structures theory explain well the results



Band structure theory explains well why nitrogen-doping DBC promotes higher photodegradation performance of TC and MB than DBC;

NDBC produces $\cdot O_2^-$ and ·OH, while DBC can only produce $\cdot O_2^-$.

Fig. 3. Band structures of NDBC and DBC.

Y. Yong et al., Science of the Total Environment 820, 153300 (2022).

Conclusions

- **nitrogen doping promotes photodegradation performance of biochar-derived DBC for TC and MB.**

  That's because

  1) N-doping increases the valence-band energy and the band gap, as well as the separation efficiency between the photo-generated electrons and holes.

  2) the photo-stabilities of TC and MB contribute to better degradation of TC by NDBC.

- **The photodegradation intermediates of TC**

  produced by NDBC have less aromatic structure and are less toxic than those produced by DBC. This information will be helpful in thoroughly understanding the photochemical behavior of nitrogen-doped dissolved black carbon.