Enhanced Mechanical Properties of CFRP Composites via a Hydroxylated MXene/CF Core-Shell Structure

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Introduction

MXene nanoplatelets have proven effective towards reinforcing the mechanical properties of CFRP composites. After hydroxylation treatment, h-MXenes displayed a fibrous morphology while the oxygen-containing functional groups on their surface increased, which further optimized the interfacial properties.

Objective

This work aims to reveal the influence of hydroxylated MXene nanoplatelets on the mechanical properties of CFRP composites as well as their underlying reinforcing mechanism.

Methods

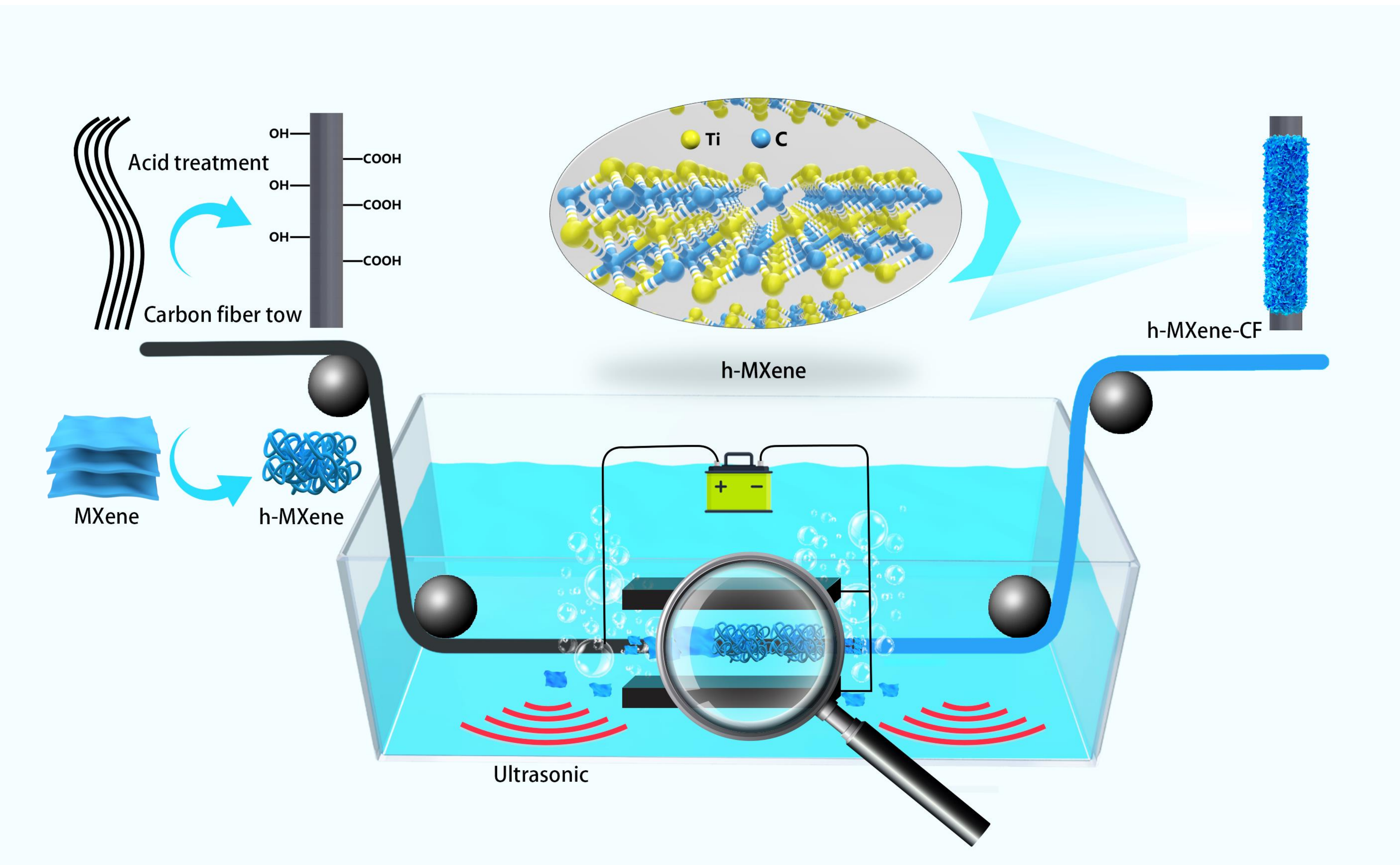

Fig.1 The electrophoretic deposition (EPD) process that was used to deposit the hydroxyl-functionalized MXenes onto CFs.

- The hydroxylation process was realized by alkali etching under N_2 atmosphere.
- A series of hydroxyl-functionalized MXenes were used to coat CFs via low concentration electrophoretic deposition (EPD) process.

Results

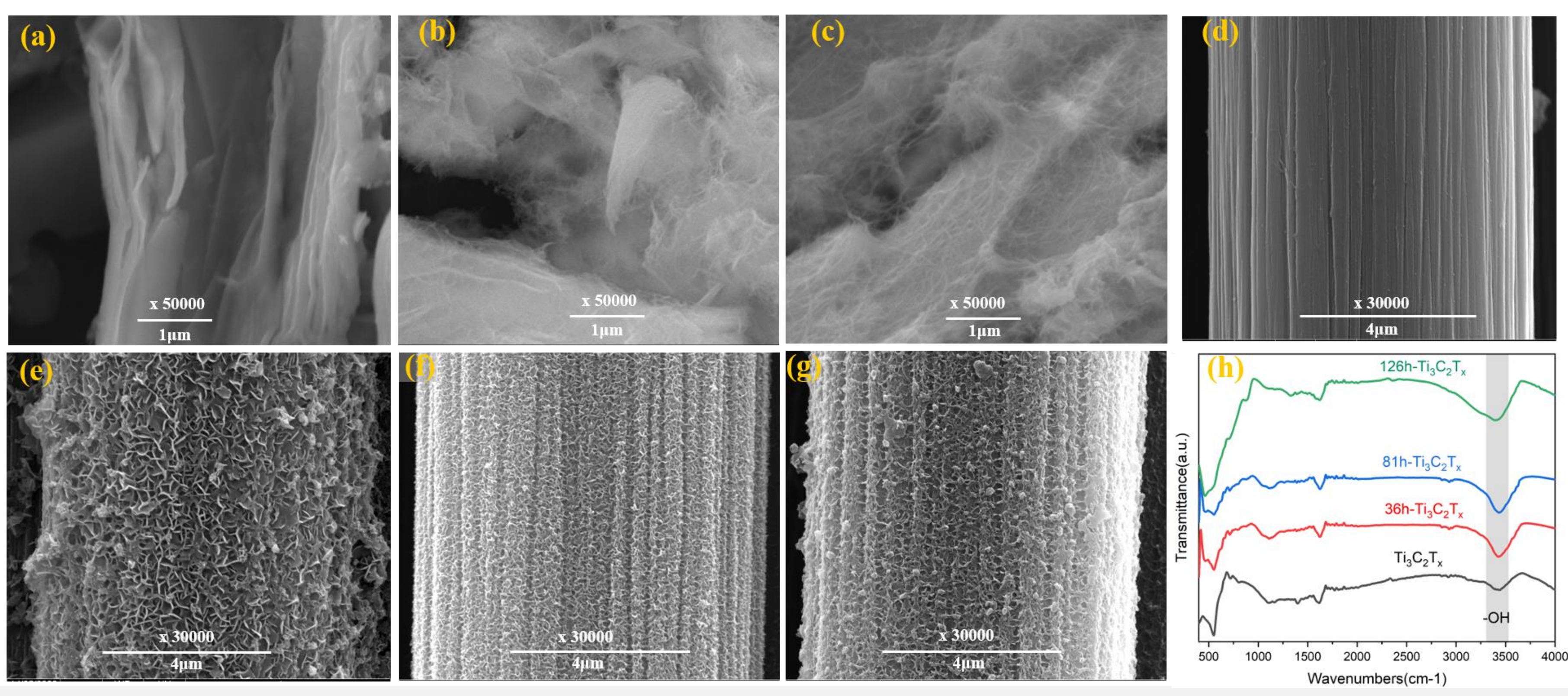

Fig.2 The morphologies of hydroxylated MXenes at different etching-times (a-36h; b-81h; c-126h) and the corresponding images after coating onto the CFs (e-g), pretreated CF before EPD process (d), FTIR results (h).

- The topography of h-MXenes (Fig.2a) revealed a transformed from nanosheets into flocculent networks (Fig.2b-c) as the etching time extended from 36h to 81h and 126h.
- The deposition of MXenes onto CFs was highly homogeneous as a result of the effectiveness of the EPD process (Fig.2e-g).
- The content of the hydroxy groups increased as hydroxylation process evolved over time, as observed from the stronger hydroxyl peaks in Fig.2（h）.

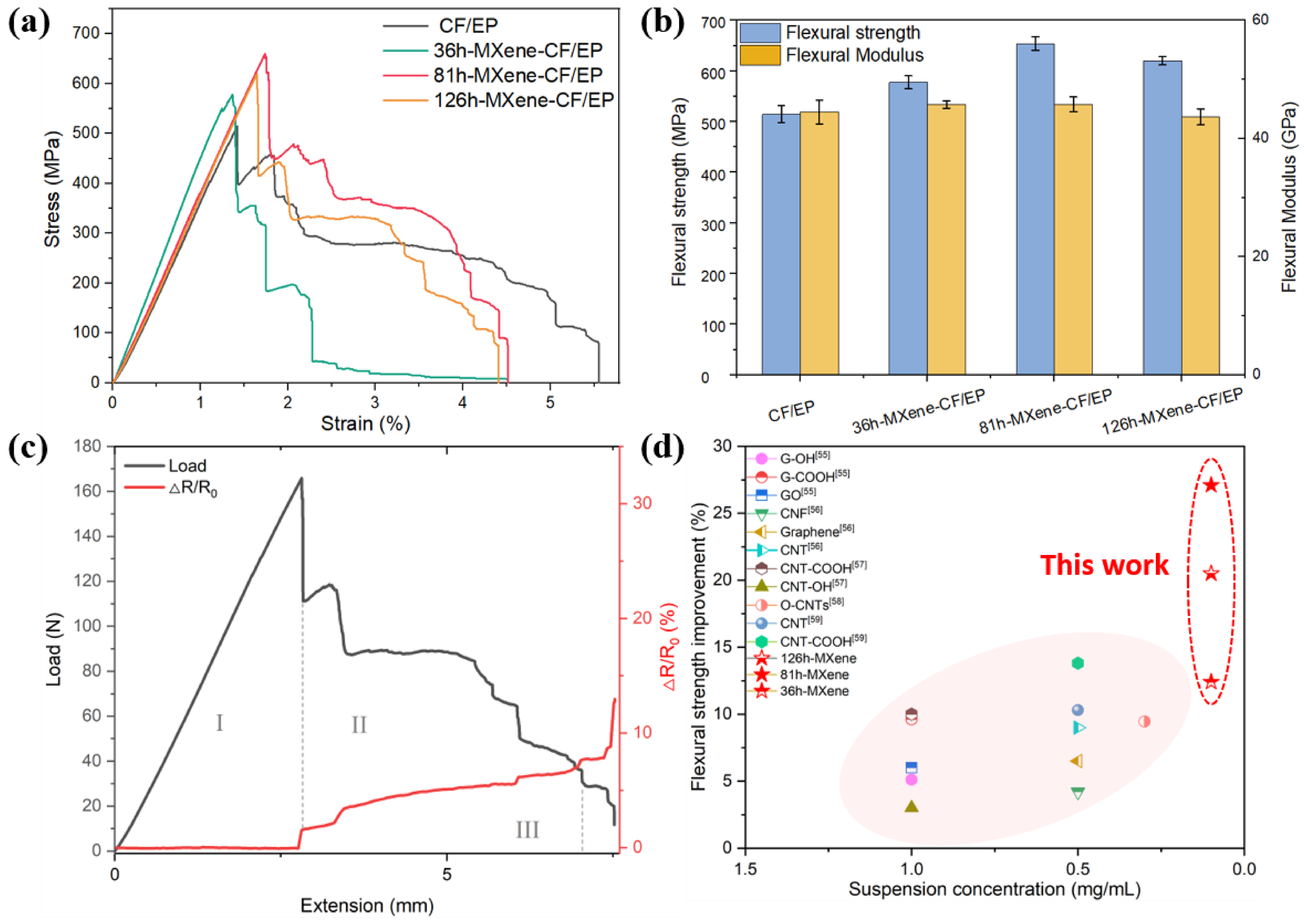

Fig.3 Flexural performance of the h-MXene modified CFRP composites (a-b); the electromechanical response of h-MXene-CF/EP after 81h of etching (c); comparison of our results with literature (d).

- After 36h/81h/126h of etching, the h-MXenes coated on CFs enabled an improvement of the flexural strength of the modified CFRPs by 12.4%, 20.5% and 27.1%, respectively (Fig.3a-b).
- The results from the resistance change over the relative intrinsic resistance ($\Delta R/R_0$) (Fig.3c) agree well with the damage evolution of h-MXene-CFRP composites.
- Our work realised a superior mechanical enhancement effect via the low-concentration EPD of h-MXene, compared to the state of the art (Fig.3d).

Conclusions

- The hydroxylation treatment had an important influence on the morphology and the properties of the MXene nanoparticles.
- The hydroxylated MXenes acted positively towards enhancing the CFRP mechanical properties when deposited onto the CFs via EPD.
- Various alkali etching times were adopted to optimise the reinforcing effects of hydroxylated-MXenes; 81h was proven the optimal etching time towards achieving the best CFRP mechanical performance.
- The abundance of hydroxyl groups as well as the larger specific surface area of hydroxylated-MXenes contributed to the formation of hydrogen bonds and mechanical interlocking, which enabled effective mechanical reinforcement.

References

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