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功能高分子材料绿色制备与循环利用实验室
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Ultralow Cu^{2+} - doped polyelectrolyte complex imparts excellent flame retardancy to nylon-cotton fabric

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INTRODUCTION

Nylon-cotton (NC) fabrics are widely used in military and industrial applications, but their high flammability still remains a serious problem. Simple polyelectrolyte complex (PEC) can not solve this due to so called "scaffolding effect". Inspired by the role of small ions in PECs, $CuSO_4$ is used to prepare Cu^{2+} -doped complexes (CPEC) and the amount of extrinsic and intrinsic ion pairs is controlled by the concentration of it. In this way, CPEC with appropriate viscosity and wettability is obtained by adjusting the proportion and content of polyelectrolyte complex and $CuSO_4$, which imparts flame retardancy to NC.

EXPERIMENTAL

PEC and Cu^{2+} -doped PEC was coated onto NC fabric through scraping, curing and dying.

RESULTS & DISCUSSION

Polyelectrolyte complex solution

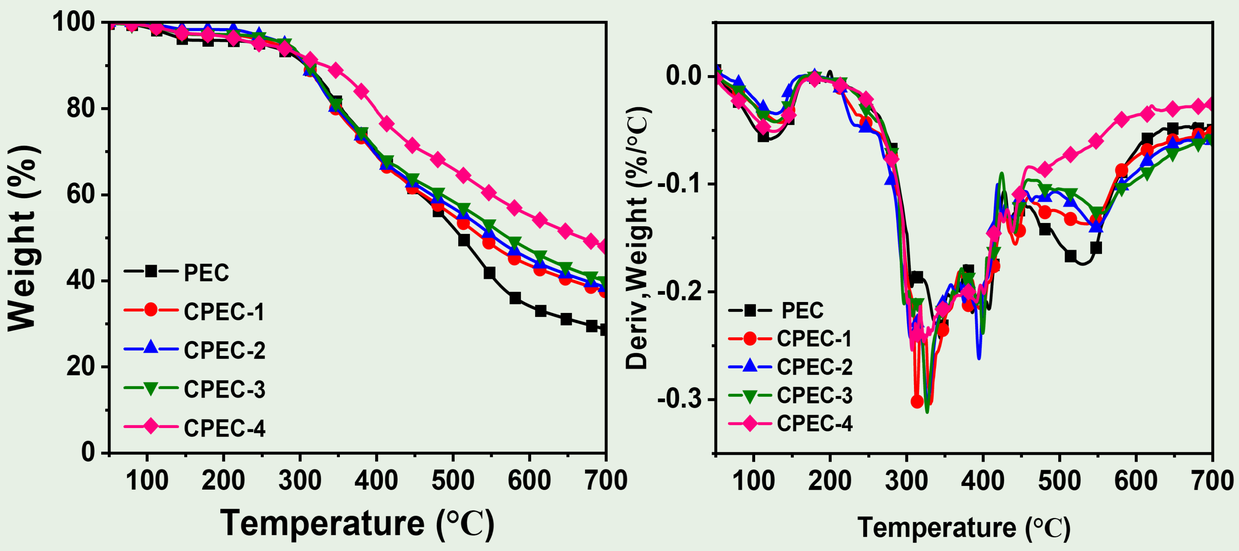

Figure 1. TGA and derivative thermogravimetry (DTG) curves of PEC, CPEC-1, -2, -3, and -4 at a heating rate of 10 °C·min^{-1} in a nitrogen atmosphere.

Flame retardancy

Table 1. UL-94 and LOI results.

sample	weight gain (wt%)	LOI (%)	damaged length (cm)
neat	-	20±0.5	Entire sample
NC-1	21 ± 1	25±0.5	120±10
NC-2	21 ± 1	27±0.5	130±10
NC-3	21 ± 1	26±0.5	Entire sample
NC-4	21 ± 1	25±0.5	Entire sample

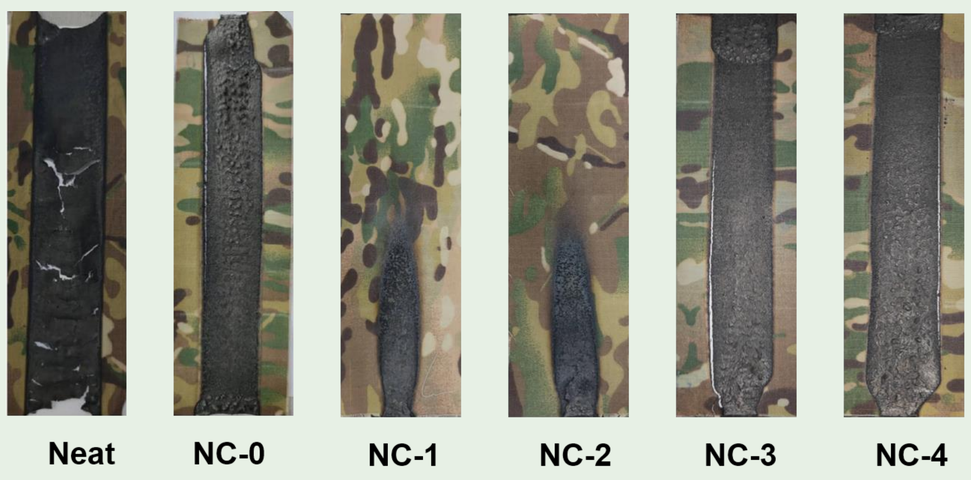

Figure 2. Photographs of NC fabrics after VFT.

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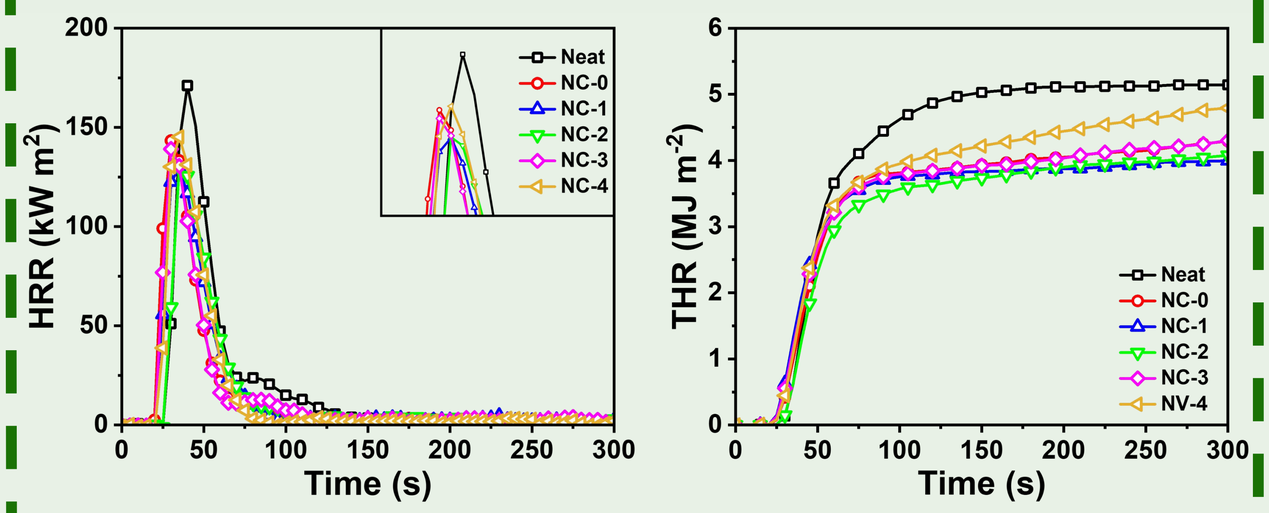

Figure 3. Heat release rate (HRR) and Total heat release (THR) for neat NC, NC-0, -1, -2, -3, and -4.

According to the above mentioned results, CPEC-1 is ideal because the addition of $CuSO_4$ has no negative effects on PEC.

In addition, fabric coated by CPEC-1, NC-1, shows great flame retardancy, which can be seen in the results of VFT and Cone.

Flame retardancy mechanism

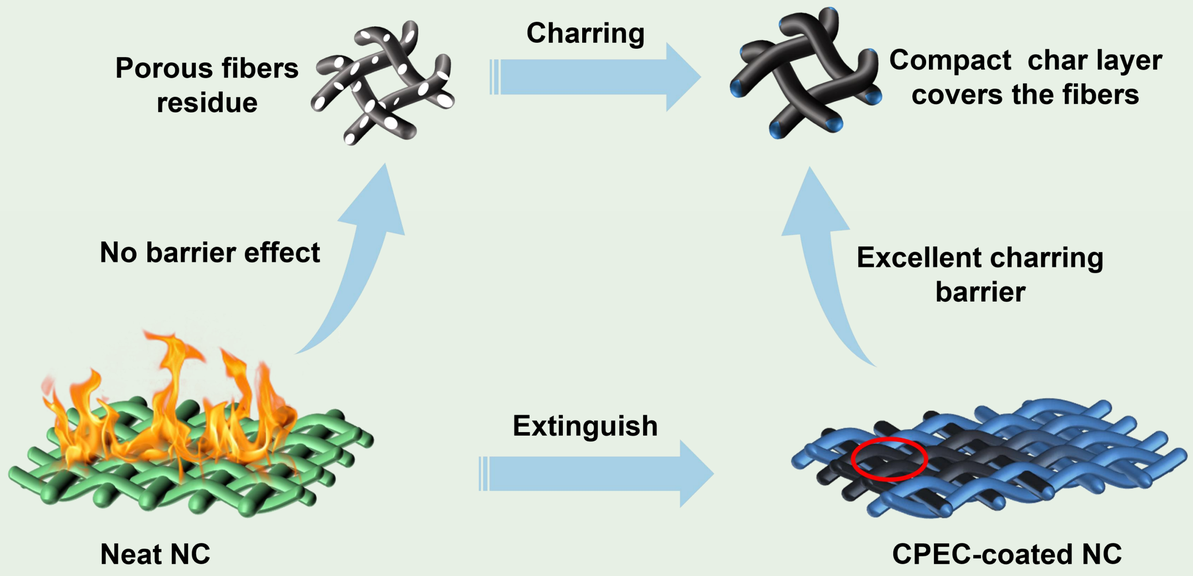

Figure 4. Flame retardant mechanism of the CPEC-treated NC fabric.

CONCLUSION

The NC fabric was rendered self-extinguishing with a water-based coating that consists of APP, PEI, and copper sulfate. A 21 wt % treatment can self-extinguish within seconds and pass the VFT. It was revealed that CPECs form a very compact char. Cu^{2+} acts as both complexation and catalytic agents.

According to the results of VFT, it was revealed that the amount of Cu^{2+} in the PECs that could pass the VFT was 0.067 wt %. The efficacy and simplicity of this coating show great potential for fire protection of textiles

PUBLICATION

[1] M. J. Chen, et.al., ACS Applied Materials & Interfaces 48, 54225-54232 (2022).

REFERENCES

[1] Grunlan. J. C., et.al. , Polym. Degrad. Stab 122, 1-7 (2015).
[2] M. J. Chen, et.al., Composites, Part B 175107189 (2019)