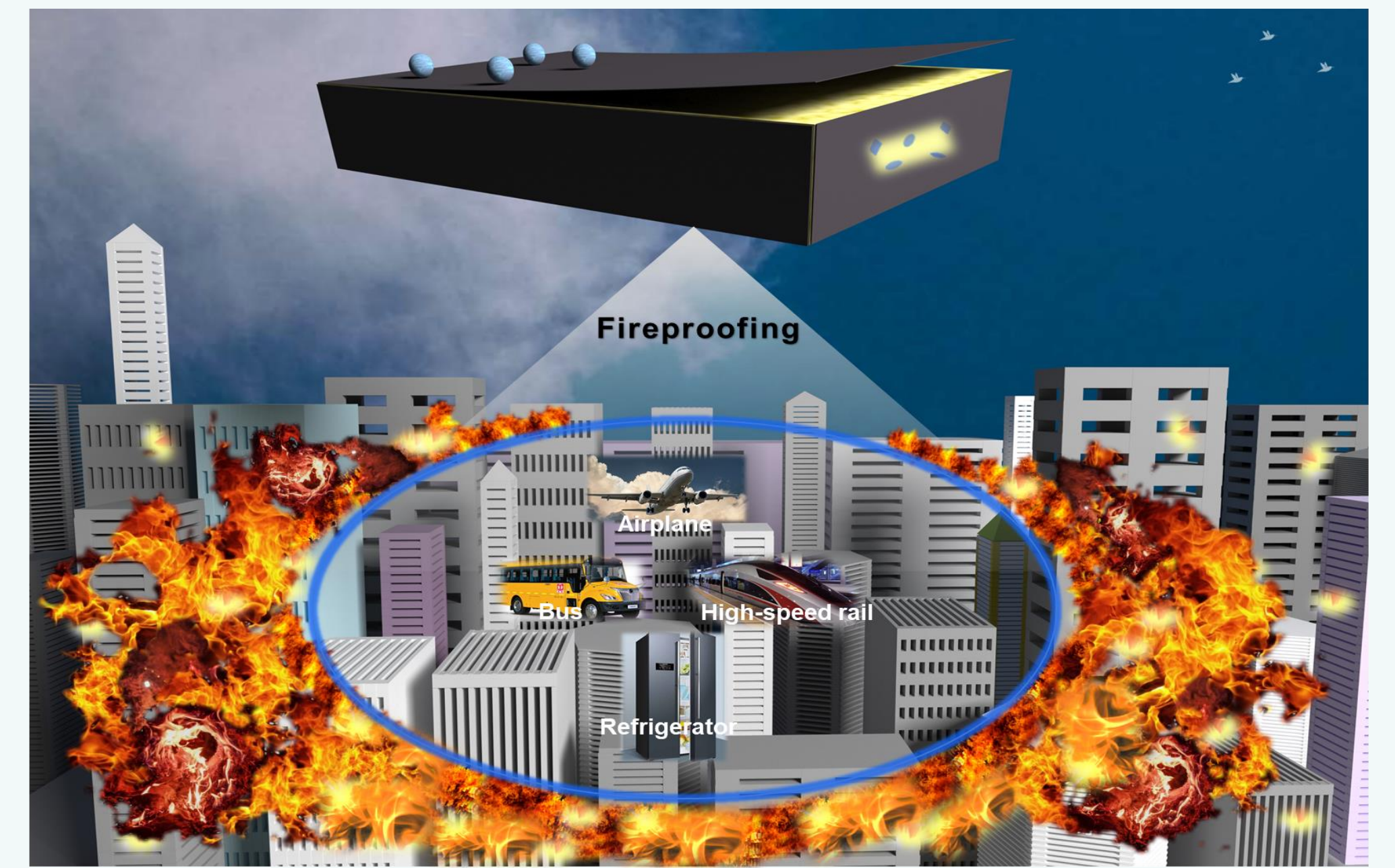


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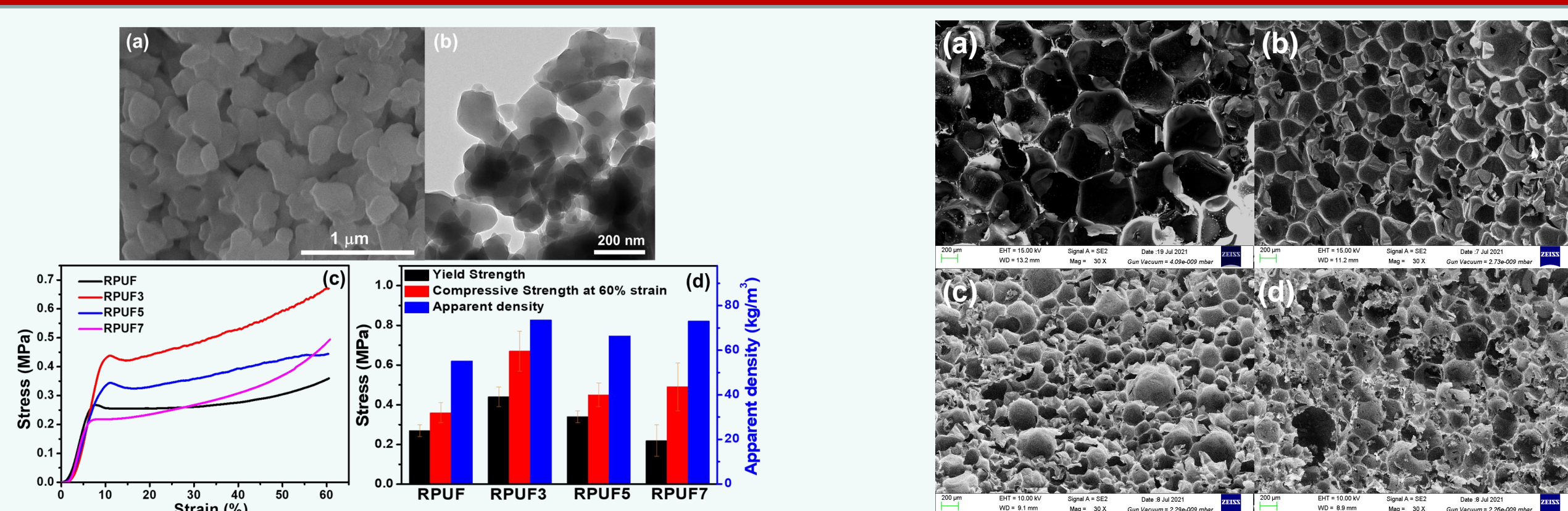
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## Abstract

The adoption of rigid polyurethane foam (RPUF) in the construction industry and rail transit is one of the great ways to energy conservation and emissions reduction. However, RPUF is troubled by its inherent flammability and easy aging caused by water chronically attacking due to locating on the exterior of objects. Herein, an outstanding flame retardant, good hydrophobic and mechanically reinforced RPUF nanocomposite was designed and prepared by combining nano-reinforcement and surface treatment. Results indicate that adding 3 wt.% HACP-PA to RPUF increase its yield strength and compressive strength (at 60% strain) by 63 % and 86 %, respectively. The nanosheets and coatings endow RPUF with an LOI as high as 42.5 %, a satisfactory V-0 rating in UL-94 test, 44 % reduction in the PHRR, 507 % increase in residues, acceptable hydrophobicity and good thermal insulation. Besides, PDA@ODT deposited on fabrics shows self-healing hydrophobicity. In summary, this work provides a bio-based, low-cost and eco-friendly method for developing multifunctional flame retardant materials with superior comprehensive properties.

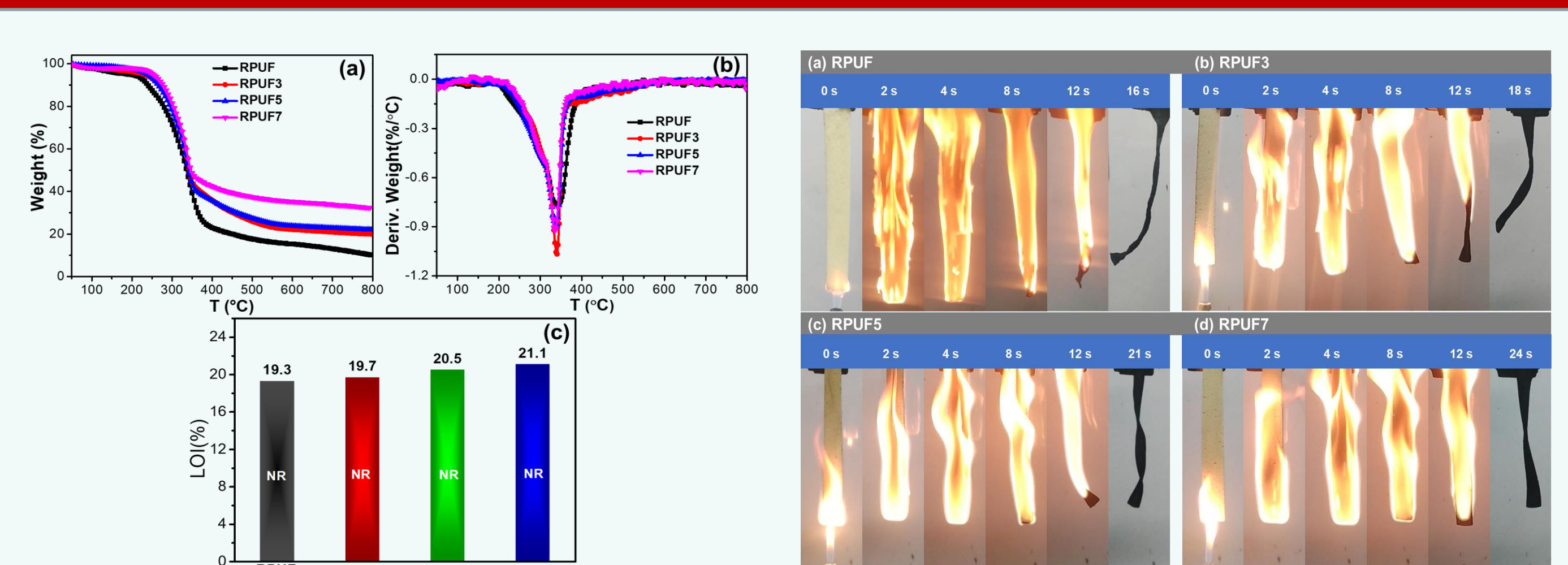


## Physical-mechanical properties



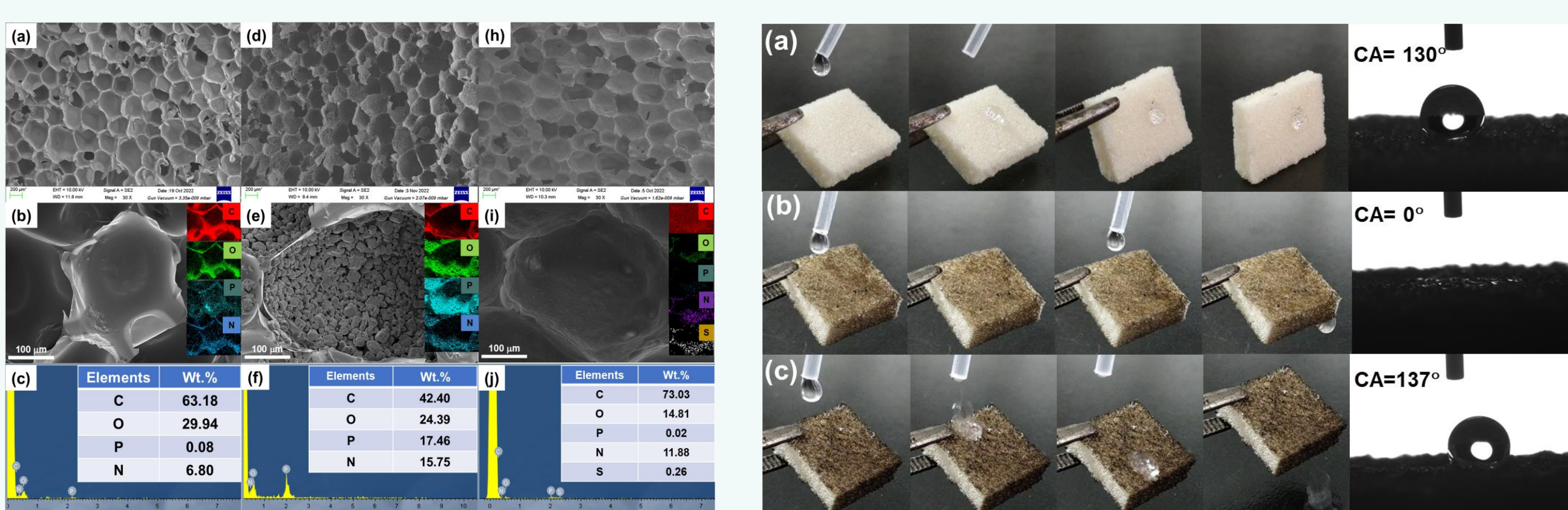
- The addition of 3 wt.% nanosheets to RPUF showed the best yield strength and compressive strength.
- The cell sizes of RPUF composites decrease gradually with increasing HACP-PA loadings.
- The HACP-PA nanosheets exist in a polydisperse state with a thickness varying from approximately 10 to 50 nm.

## Thermal stability and fire behavior



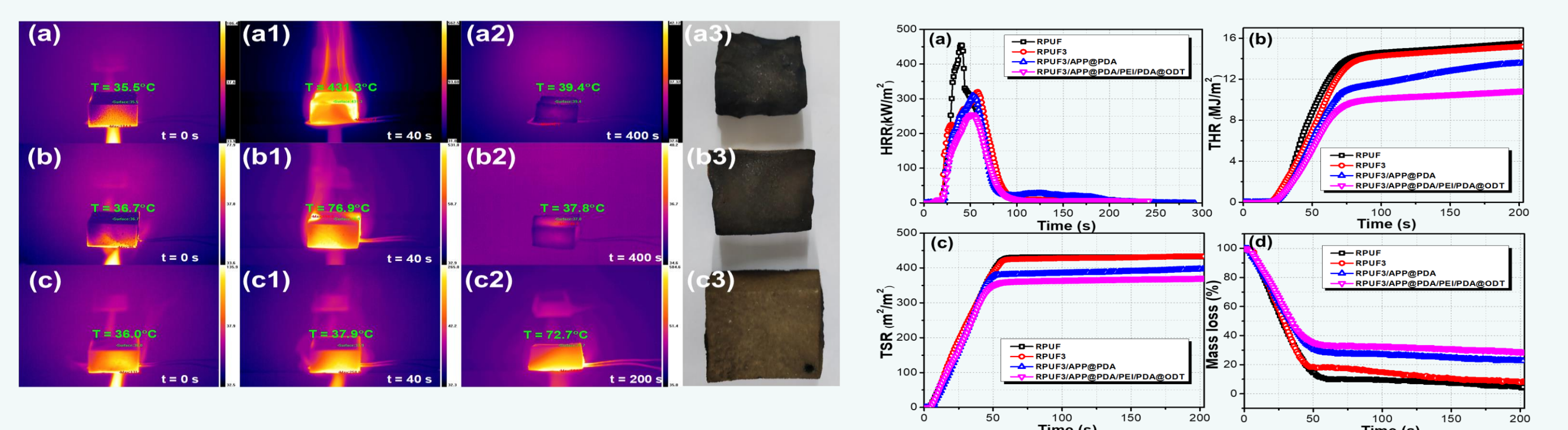
- The HACP-PA nanosheets exhibit remarkable catalytic carbonization capacity on RPUF under nitrogen atmosphere.
- With increasing HACP-PA addition, the flame intensity decreased slightly, which is due to the catalytic dehydration and carbonization of nanosheets impedes the rate of combustion, but all RPUF composites still have no ratings in the UL-94 test.

## Hydrophobic properties



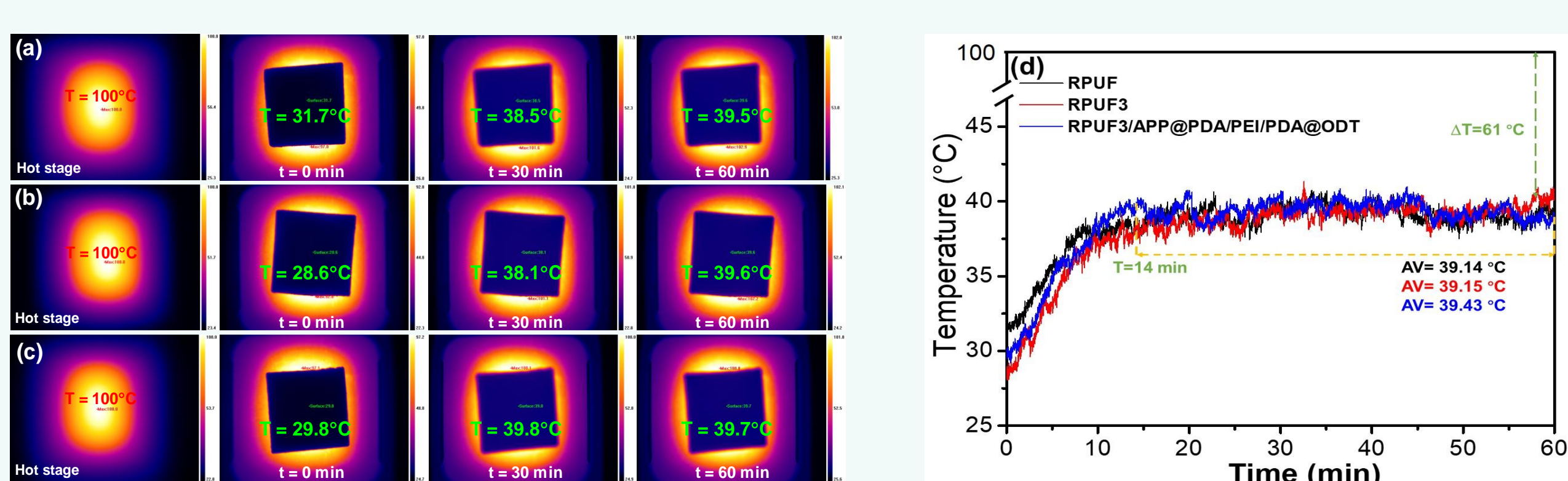
- After imparting a flame retardant coating, the surface of the RPUF3 is well covered by APP@PDA particles. Continuing to apply PEI/PDA@ODT on the surface of RPUF3/APP@PDA, the APP@PDA particles are completely covered while the RPUF3 surface become smooth again.
- The APP/PDA coatings exhibit strong water absorption. After the APP@PDA coating surface continues to be covered with PEI/PDA@ODT, the CA increases to 137°, which is higher than uncoated RPUF3.

## Flame retardant properties



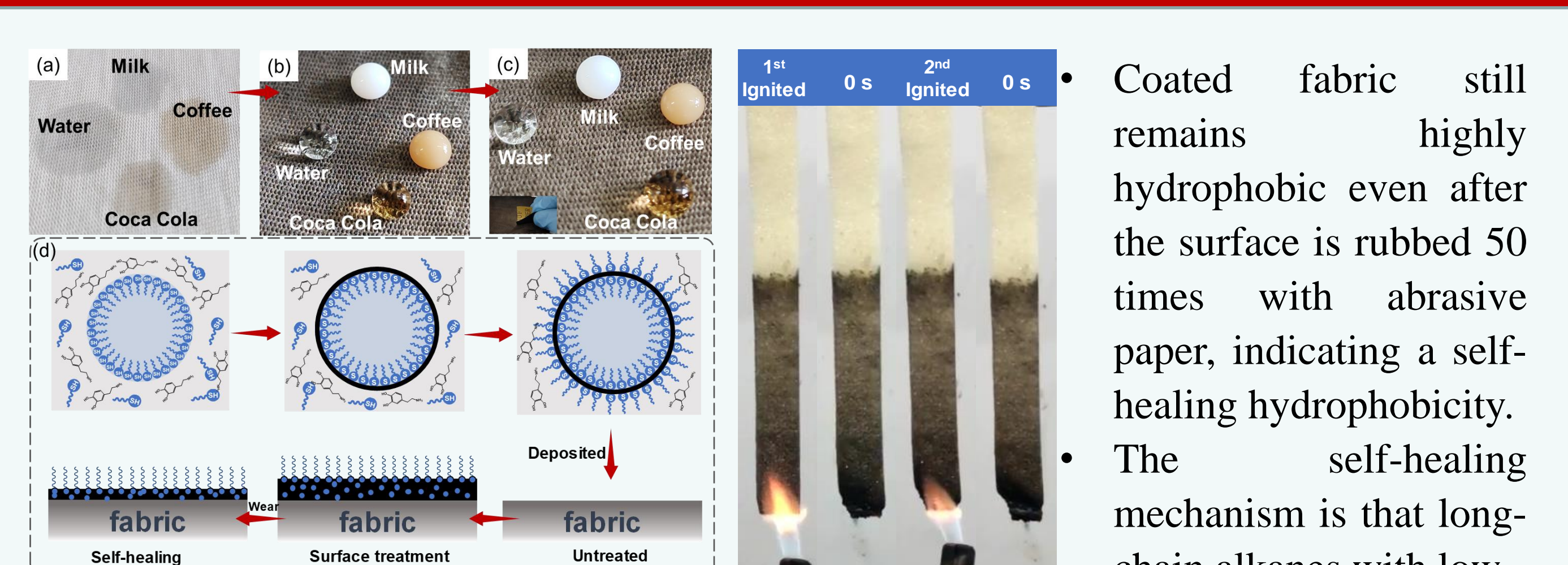
- Coated RPUF3 exhibits extremely high fire resistance.
- The HACP-PA and coatings endow RPUF a high LOI and V-0 rating in UL-94.
- Coated RPUF3 showed the best overall fire performance in the cone calorimetry test.

## Thermal insulation



- Neither HACP-PA nor coating significantly affected the thermal insulation performance of RPUF3.
- The samples with thickness of 3 cm achieve a temperature difference ( $\Delta T$ ) of 61 °C, suggesting its good thermal insulation property.

## Other applications of coatings



- The self-healing mechanism is that long-chain alkanes with low surface energy in the inner layer are continuously released after wear.
- The flame retardant coating applied to the flexible polyurethane foam still exhibits excellent flame retardancy.