Multifunctional nanostructured composites containing biomass-derived functional additives

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Due to their superior thermal stability and chemical resistance, epoxy resins represent a primary choice in several industrial applications, including the fabrication of protective and functional coatings. The addition of properly designed fillers allows for the preparation of coatings showing surface hydrophobicity, anti-icing, shape recovery capability, luminescence, and improved flame retardance, required to contrast the high flammability of such materials. Herein, we propose two approaches to enhance these properties by sustainable sol-gel methodologies: the functionalization of hemp microparticles (HMPs), obtained from waste hemp fibers, to turn them into hydrophobic and anti-icing fillers [1], and the tailoring of carbon quantum dots (CQDs), hydrothermally synthesized starting from humic acids, to make them able to act as flame retardant and hydrophobic agents [2]. To give an idea, thanks to their suitable surface chemistry and hierarchical rough structure, 2 wt.% of hydrophobic HMPs, cast on aeronautical carbon fiber-reinforced panels, showed up to 30° higher water contact angle (CA) at room temperature and doubled icing time at -30 °C than unfilled epoxy resin coatings. On the other side, 0.1 wt.% of silanized CQDs added into the epoxy matrix, without using phosphorus and halogen-based flame retardants, could lead to nanocomposites exhibiting photoluminescence, high hydrophobicity (up to 137° of CA), fire resistance, and heat/flame-triggered shape recovery features.

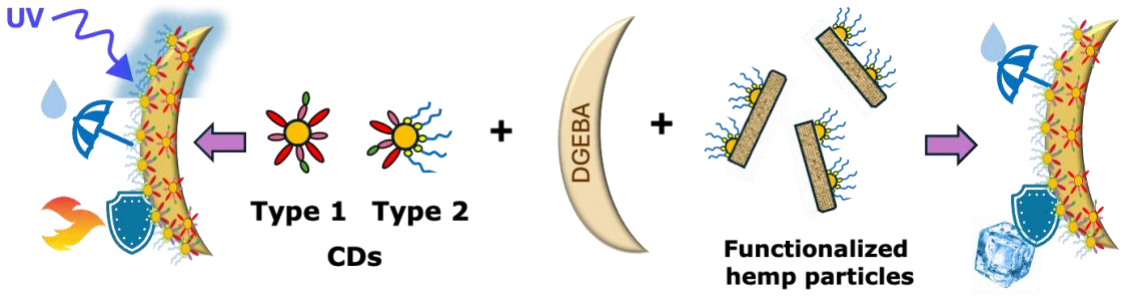

Figure 1. Synthesis strategies for the production of hydrophobic epoxy-based coatings.

References

[1] ACS omega 8 (26) (2023) 23596-23606.
[2] Chemical Engineering Journal 484 (2024) 149327.