

Editorial

Coating a Sustainable Future

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Abstract: The increasing demand for more sustainable products, now more than ever, has been driving research efforts in academia and industry to develop novel coatings solutions. This special issue aims at exploring opportunities for developing such coatings that incorporate elements of sustainability in their design by utilizing green materials or processes while offering desired performance in a variety of applications.

Keywords: green coatings; biobased coatings; sustainability; renewable coatings

Sustainability, green materials and processes, as well as biobased products are currently some of the most discussed topics in academia and industry. As the attention towards the sustainability and greenness of materials grew over the years, polymeric coatings also evolved from basic coatings to coatings with more diverse formulations, e.g., moving away from organic solvent-based to water-based coatings [1] and increasing their durability. Although consumer awareness and government regulations are two of the main driving forces for research into more sustainable coatings, competitive performance and cost play key roles in making research and development investment decisions in this field. Hence, today, the sustainability aspects of coatings have moved beyond the reduction of volatile organic compounds (VOCs) and have been increasingly directed towards adopting energy- and resource-saving strategies, the incorporation of renewable materials with more versatile functional capabilities and lower prices [2], as well as waste minimization through the entire supply chain of the coatings. However, challenges still exist in identifying the coating materials and processes that can meet most of these criteria while providing environmental and health benefits. For example, although incorporating biobased materials in the formulations of coatings (one of the green chemistry principles) is considered a move to increase their sustainability, mostly, those biobased formulations are in higher demand that can act as a drop-in component rather than the requiring additional cost of modifying the infrastructure of the production line. Therefore, constant advancement towards functionally equivalent or better as well as cost-effective materials is needed.

In response to such a challenge, this Special Issue focuses on investigating a wide range of green coatings, using either renewable materials and/or greener processes. In particular, the topics of interest included:

- Using renewable raw materials in coating formulations (vegetable oils or other plant-based materials like cellulose, lignin, tannin, eel grass, carbohydrates, chitosan, protein);
- Recycled polymers used for coatings;
- Fermented or bacterially derived materials used for coatings;
- Novel designs of material synthesis and formulation processes that reduce health and environmental impacts (e.g., carbon footprint, energy consumption, and toxicity);
- Life cycle environmental impact assessment and techno-economic analysis of green coatings;
- Reducing the use of toxic components (e.g., anti-corrosion materials);
- Green coatings in biomedical, electronic, automotive, and construction applications;

- Green coatings for energy saving in the construction industry.

To that extent, in this Special Issue, Lindner et al. (2019) focused on improving the performance of biobased coatings for packaging purposes. Their tested method showed a better stabilization of wax suspension as the water–vapor barrier coating. In another article of this issue, Dai et al. (2018) investigated the mechanical and thermal properties of a eugenol-based main-chain type benzoxazine polymer, that is one of the main components of common thermosets. They synthesized and cured a series of biobased benzoxazine oligomers from eugenol derivatives, and reported that all the coatings they prepared and tested exhibited a high hardness, excellent adhesion, good flexibility, low moisture absorption, and outstanding solvent resistance.

Kulsiriswad et al. (2017) dedicated their work to synthesizing and investigating the properties of biobased oligolactide acrylates that can be used as starting materials for UV-curable screen-printing applications. They showed that all of their formulated biobased ink films cured by UV radiation were very flexible with excellent adhesion, high impact resistance, and excellent water resistance.

Other articles in this Special Issue investigated the implementation of green processes and green materials in coatings. An example of those investigated approaches is synthesizing N-doped TiO₂ materials. N-doped TiO₂ materials exhibit broad absorption in the visible region, which can allow the utilization of a large part of the solar spectrum. This has attracted attention for environmental and energy applications, such as the photocatalytic degradation of organic pollutants or their use in clean energy production devices. In their study, Hsu et al. (2020) investigated the effect of increasing the NH₃/O₂ gas mixture ratio on narrowing the bandgap of N-doped TiO₂ to allow better absorption of visible light. They showed that the bandgap energy can decrease to ~2.54 eV when the NH₃/O₂ gas mixture ratio is increased to 3.

In another study, Salca and Hiziroglu (2019) evaluated the surface roughness and hardness of laminated wood-based composite panels as a function of exposure to a high relative humidity (RH) of 65%. They reported that the change in surface quality and hardness was higher for the raw samples compared with the overlaid ones, providing useful information for enhancing the manufacturing and service life of overlaid composite panels.

Finally, Zhang et al. (2020) investigated the effect of treating basalt fabrics with plasma prior to coating them with silicone to enhance the heat transfer resistance for protective clothing purposes. They demonstrated that treatment with plasma changed the fibers physically and enhanced the uniformity of the silicone coating significantly compared to the silicone-only coated basalt fabrics.

Despite the extensive research and rush for innovative green solutions, the interpretation and effectiveness of the sustainability of those solutions are still debated. Although sustainability and greenness have shared ideas in their concept and may often be considered equivalent, their definitions at most times differ. In one of the common sustainability definitions, a product/process is often considered sustainable if its associated activities do not result in irreversibly damaging the environment. Greenness, on the other hand, calls for following green chemistry/engineering principles. Nevertheless, addressing such complex issues requires continuous research efforts into understanding the possibilities and challenges that come with innovative “green” solutions. Performing a holistic sustainability assessment, while including coating’s end-of-life stage, and using metrics such as life cycle assessment (LCA) [3] and techno-economic analysis (TEA), is an essential step that must accompany the proposed solutions to guide future research directions [4], as well as facilitate the decision-making for the coating industry in using greener materials and processes.

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