Modification of paper surface with hydrophobic biobased nanocomposite coatings polymerized with UV-light and plasma

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Paper coatings, although imperceptible at first glance, are present on the surface of many objects used in our daily life such as food packaging, disposable tableware made of cardboard, release liners – carriers for stickers, tapes, labels, hygienic products etc. Such coatings are mostly based on non-recyclable and non-biodegradable chemicals. Would it be possible to replace them with biobased alternatives? Here we present novel results of our research on the plants-based hydrophobic nanocomposite coatings for paper produced by two sustainability-oriented coating technologies – UV and plasma polymerization. Acrylated epoxidized linseed oil (AELO) as a prepolymer resin was synthesized according to the protocol described in paper [1]; vanillyl alcohol methacrylate (VAM) and eugenyl methacrylate (EM) resin were obtained by methacrylation reaction of vanillyl alcohol and eugenol with methacrylic anhydride following adopted procedure from the reference [2]. Sea shells´ particles (SS) and cellulose nanocrystals (CNC) were modified with (3-chloropropyl)trimethoxysilane and used as biobased fillers. 1-hydroxycyclohexyl-phenyl ketone (Irgacure 184) was used as a photoinitiator and poly(dimethylsiloxane-co-(2-(3,4- epoxycyclohexyl)ethyl) methylsiloxane (PDMS-ECEMS) was added as a hydrophobic additive to the UV-cured formulations. Curing formulations were applied to Glassine paper (1-4 µm) and exposed for 30 seconds to UV light with an intensity of 650 $mJcm^{-2}$ in average. AELO resin was diluted with isosorbide methacrylate prior to UV curing. VAM and EM coatings reinforced with SS and CNC particles were additionally studied by argon plasma deposition on silicon wafer being exposed to energy of 50 – 100 W (50 passes) with a monomer flow ranging from 10 to 50 $\mu lmin^{-1}$ and plasma deposition rate of 50 mms^{-1}. Structural changes were monitored by FT-IR and XPS spectroscopy; surface of the coatings was analyzed by SEM microscopy, and hydrophobic properties of the coatings were characterized by contact angle (CA) and surface energy (SE) measurements. FT-IR analysis confirmed a successful conversion of double bonds during polymerization. XPS-analysis indicated that in average 8% of Si atoms was attached to SS and 11% to CNC particles. SEM analysis showed a uniform distribution of SS and CNC in the polymer matrix. The highest CA (111°) and SE (16 mNm^{-1}) were determined for both AELO coatings containing CNC and SS particles, while CA of 106° was determined for EM and VAM nanocomposite coatings (SE_{EM}=15 mNm^{-1}; SE_{VAM}=17 mNm^{-1}). The results revealed the potential of the studied resins and fillers to be used in paper coatings as sustainable materials and our future work will be focused on optimizing the barrier properties of the UV- and plasma-polymerized coatings.

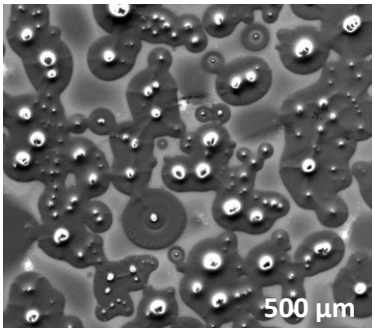

Fig. 1. SEM image of EM-CNC plasma-polymerized nanocomposite.

[1] A. R. Mahendran *et al*., Progress in Organic Coatings, **74**, 697–704 (2012)
[2] J. F. Stanzione *et al.*, ChemSusChem, **5**, 1–8 (2012)