Magnetron sputtering of copper onto liquids for the production of flexible polymer composites

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Low pressure (1 Pa) cold plasma–based magnetron sputtering (MS) of atoms onto liquids allows obtaining dispersions of small nanoparticles (NPs). The main advantages of the method are its reproducibility and high purity of the final NPs, since only two components – target material and liquid molecules – are present in the solution, and no additional reducing or stabilizing reagents are required. This work is the first example of usage of poly(ethylene glycol) methyl ether acrylate ($PEGA_{480}$) in the MS process; this compound was chosen as it withstands vacuum and can be used in photopolimerization processes. Deposition of copper onto $PEGA_{480}$ leads to the formation of the colloidal solutions of copper oxide NPs due to the rapid oxidation of primary metal copper NPs after the contact with the solvent and atmosphere. Concentration of NPs in the final solution can be easily controlled by the MS conditions by varying e.g. the deposition time and/or sputter power. Our data suggest that in our working conditions, the polymerization of the $PEGA_{480}$ matrix already starts during the plasma treatment. Colloidal solutions of copper oxide NPs in $PEGA_{480}$ combined with small amounts of poly(ethylene glycol) diacrylate as the crosslinker are used for further fast copolymerization under near-UV exposure leading to the formation of a polymer composites. Optical and mechanical properties of the final polymer composite films have been studied. Present synthetic approach combining MS and photopolymerization technique opens a door for the design of a wide range of ultra-pure NP-containing polymer composites with advanced properties.