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ZnO-on-cellulose hybrids in action: from experimental design to bacterial decontamination

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Design of experiments (DOE) allows for improving the synthesis parameters of a large variety of functional materials, by determining a model to predict synthesis outcomes and the potential interactions among the synthesis variables, thus reducing process variability, time, number of experiments, and cost. To the best of our knowledge, the application of DOE to ZnO materials is quite limited, mainly because of the initial sub-optimal synthesis conditions. For instance, the seminal work from the group of prof. Wang reporting the "pick-the-winner rule" and "one-pair-at-a-time" analysis only allows for sequentially identifying optimal reaction settings [1], without understanding the effects due to interactions between the parameters. Recent works included DOE for producing ZnO for dyes absorption in aqueous solutions but without producing a surface response [2]. In this work, we use a central composite approach, based on a two-levels (-1; +1) design in addition to a central (0) point to test synthesis reproducibility. The design is based on a previously optimized synthesis protocol for electronic interfaces [3] and aims at understanding the effects of three parameters – i.e. Zinc precursor concentration, reaction time and KCl concentration, observing the effects on reaction yield and photodegradation efficiency of methylene blue dye. The synthesized ZnO are also characterized by ζ-potential and SEM to study their morphology. Whereas precursor concentration mainly affects reaction yield, KCl allows for increasing the (002) plane stabilization. Differently from our previous work based on ZnO/cellulose acetate composites [4], the synthesized ZnO is here absorbed (1 hour, 90 °C) onto precut ethyl cellulose or cellulose pads permitting the rapid release of ZnO when the ZnO-cellulose hybrid is soaked into aqueous solution. The photocatalysis experiments allow for the quantification of role of the three selected synthesis parameters, finally permitting to obtain a surface response. Finally, antimicrobial tests show the effective bactericidal ability of the synthesized materials on both gram-negative and gram-positive strains.

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