HÖGSKOLAN I BORÅS

Graphene: a vision to the future of smart E-Textile application

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Avhandling för doktorsexamen inom Textil materialteknik, som kommer att offentligt försvaras Milad Asadi Miankafshe den 09.06.2022 kl. 13:00 i sal M404, Högskolan i Borås, Textile Fashion Center, Skaraborgsvägen 3, Borås.
Seminariet ges på engelska

Opponent: Professor Georgios Priniotakis

Abstract

Smart textile is a term referring to the textiles that could interact with their environment, receiving input and giving output based on their applications. Among smart textiles, electrically driven smart textiles (E-textiles) are being produced by various methods and materials integrated with textile substances. Graphene is one of these compounds that could be integrated into the polymer or integrated into the textile materials such as fibres. Therefore, other elements could be doped or immobilised on the graphene nanosheets for a wider range of applications, such as catalytic and electrocatalytic systems.
However, finding the most applicable and efficient method to integrate graphene into the textile fibres and further establishing a method for catalyst immobilisation are challenging and require focused research.
Therefore, this doctoral thesis focused on the innovative concept of integration of graphene and immobilisation of iron nanoparticles on it. Evidence from the systematic experiments was gathered for the case of dip-coating of polyester textiles with graphene oxide dispersion and enhancing the electrostatic bonding between fibres and graphene oxide nanosheets. In the second step, systematic experiments were gathered for the case of immobilisation of an inorganic catalyst (zerovalent iron) on textile supports. The goal of this thesis is to establish the feasibility of a mild and applicable method for textile material supports, which requires low temperature and mild pH, and further fabrication of heterogeneous catalytic and electrocatalytic systems for wastewater treatment. Polyester was chosen as the textile support material for graphene oxide coating and catalyst immobilisation due to its availability and cost-effectiveness.
The thesis has four distinct parts related to (a) Pre-surface-charge modification of the polyester for strong electrostatic bonding between polyester and graphene, (b) Design a continuous yarn coating system for mass production of graphene-coated conductive yarns, (c) Immobilisation of Fe^0 on graphene-coated polyester textiles and optimising their feasibility in catalytic systems and (d) Design and prove the feasibility of knitting a fully textile-based reactor having two anodic and cathodic sections by using rGO-Fe^0 yarns and stainless-steel multifilament yarns, respectively as a concept of electro-Fenton wastewater treatment.
Diverse analytical and instrumental techniques were used to monitor the surface modification of the polyester textiles and conductivity of the resulting textiles; moreover, the electromechanical and electrothermal properties of the graphene-modified textiles were examined. Further, the efficiency of catalyst immobilisation, physio-chemical properties of the immobilised catalyst, and their catalytical activities in dye removal from the water was studied.
Results showed that surface charge modification of polyester fabric with both chitosan and hexadecylpyridinium chloride (HDPC) gives the most homogeneous graphene coating, resulting in high conductivity and very good fastness. Furthermore, results from scanning electron microscope (SEM), Differential scanning calorimetry (DSC), and UV/Visible spectrophotometry prove the success of immobilisation of zerovalent iron on the graphene-modified textiles.
The novelty of the research presented in this doctoral thesis is primarily attributed to the novelty of a hybrid graphene-catalyst immobilisation-grafting on polyester textile supports for wastewater treatment applications. The final concept of the thesis is to introduce the potential for assembling a fully textile-based reactor for Electro-Fenton wastewater treatments.

Keywords: graphene; graphene-coated e-textiles; catalyst immobilisation; hybrid graphene-catalyst multifunctional textiles; dye removal; e-textile; electro-Fenton; Fenton; wastewater treatment.