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ORIGINAL RESEARCH

Novel sandwiched composite electro-spun mats based on polyacrylonitrile and polyvinyl butyral for fast oil–water separation

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Abstract

In recent years, the issue on oil pollution in water has drawn continuous attention of researchers. Wastewater containing oil is generated in various industrial technologies, such as petrochemical, leather, textile, food, steel, and metal-finishing industries. Thus, oil sorbents are very commonly used during oil spills cleanup operation for their cost-effectiveness and affordability. In the present work, a novel sandwiched composite electro-spun nanofibrous mat (SCEM) was generated by electro-spinning technique. This sandwiched composite electro-spun mat was fabricated by sandwiching the chitosan-incorporated polyvinyl butyral nanofiber mat between two layers of polyacrylonitrile electro-spun mats. Surface morphology of the generated multilayer nanofibrous mat was observed by the static water contact angle measurement, SEM and FTIR analyses. SCEM was modified by alcoholysis reaction to increase the hydrophobicity and oleophilicity properties by enhancing the surface roughness. After fabrication and modification processes, oil-absorption capacities of single mats, SCEM, and modified mat designated as M-SCEM were investigated and calculated in terms of weight gains. Mats with sandwich structure exhibited excellent absorption capacities up to 100–140 times their own weight for motor oil. The obtained results suggest that these characteristics make spun bond nanofibrous mat a promising oil sorbent material for efficient oily water remediation.

Keywords Chitosan · Nanofiber · Oleophilicity · Polyacrylonitrile · Polyvinyl butyral

Introduction

Oily wastewater resulting from industries such as food, leather, textile, aluminum, and steel or metal finishing has seriously polluted the water resources and environment [1]. On the other hand, the pollution problems are mainly caused by shipping accidents, offshore or marine vessel leakage, and illegal discharges of oily wastes. At the same time, it causes a great loss of energy. Facing these challenges, there needs to be more focus on the removal of oil [2]. Even very low concentrations of oils can be toxic to microorganisms responsible for biodegradation in environment [3–5]. Until today, many different methods have been reported, which include chemical, biological, and physical approaches for oil removal [6]. In these techniques, chemical methods could create secondary pollution to the environment and biological approaches may take long time to recover the pollution and entail additional capital for the treatment. Thus, oil sorbents are very commonly used to treat floating oil on water surface because of their easy use and possibility of their collection. An ideal sorbent material should have high hydrophobicity, high oleophilicity, high uptake capacity and rate, adequate buoyancy, and good recoverability of the absorbed oil [7]. Synthetic sorbents are designed to remove oil content from water sources due to their oleophilic properties. Among the oil sorbents, non-woven fibrous mats are widely used for oil cleanups due to their scalable production. Electro-spun nanofibrous mats with small diameters can be fabricated and designed to exhibit and significantly improve chemical and physical properties by electro-spinning technique. Among different productions of nanofiber processing techniques, this simple, versatile, and most effective technique can also be applied to synthetic and natural polymers, polymer alloys, as well as to metals and ceramics. It allows to produce nanofibrous mats and membranes with several qualities, such as high porosity, pore sizes ranging from tens of nanometer to several micrometers and interconnected open

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