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Sorption Properties of Hemp Cellulosic Byproducts for Petroleum Spills and Water

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Abstract : The accidental release of petroleum products into the environment could have harmful consequences to our ecosystem. Different techniques such as mechanical separation, membrane filtration, incineration, treatment processes using enzymes and dispersants, bioremediation, and sorption process using sorbents have been applied for oil spill remediation. Most of the techniques investigated are too costly or do not have high enough efficiency. This study was conducted to determine the sorption performance of hemp byproducts (cellulosic materials) in terms of sorption capacity and kinetics for hydrophobic and hydrophilic fluids. In this study, heavy oil, light oil, diesel fuel, and water/water vapor were used as sorbate fluids. Hemp stalk in different forms, including loose material (hammer milled (HM) and shredded (Sh) with low bulk densities) and densified forms (pellet form (P) and crumbled pellets (CP)) with high bulk densities, were used as sorbents. The sorption/retention tests were conducted according to ASTM 726 standard. For a quick-purpose application of the sorbents, the sorption tests were conducted for 15 min, and for an ideal sorption capacity of the materials, the tests were carried out for 24 h. During the test, the sorbent material was exposed to the fluid by immersion, followed by filtration through a stainless-steel wire screen. Water vapor adsorption was carried out in a controlled environment chamber with the capability of controlling relative humidity (RH) and temperature. To determine the kinetics of sorption for each fluid and sorbent, the retention capacity also was determined intervalley for up to 24 h. To analyze the kinetics of sorption, pseudo-first-order, pseudo-second order and intraparticle diffusion models were employed with the objective of minimal deviation of the experimental results from the models. The results indicated that HM and Sh materials had the highest sorption capacity for the hydrophobic fluids with approximately 6 times compared to P and CP materials. For example, average retention values of heavy oil on HM and Sh was 560% and 470% of the mass of the sorbents, respectively. Whereas, the retention of heavy oil on P and CP was up to 85% of the mass of the sorbents. This lower sorption capacity for P and CP can be due to the less exposed surface area of these materials and compacted voids or capillary tubes in the structures. For water uptake application, HM and Sh resulted in at least 40% higher sorption capacity compared to those obtained for P and CP. On average, the performance of sorbate uptake from high to low was as follows: water, heavy oil, light oil, diesel fuel. The kinetic analysis indicated that the second-pseudo order model can describe the sorption process of the oil and diesel better than other models. However, the kinetics of water absorption was better described by the pseudo-first-order model. Acetylation of HM materials could improve its oil and diesel sorption to some extent. Water vapor adsorption of hemp fiber was a function of temperature and RH, and among the models studied, the modified Oswin model was the best model in describing this phenomenon.

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