

Biodegradable Natural Fibre-Based Coalescence Filter and Sorbent for Oil Separation from Oily Wastewater

Oil-in-water emulsion is released into the wastewater by many industries, frequently in quantities that are hazardous to the environment. Oily wastewater is treated using porous media like coalescence beds and membranes. Membrane filtration is limited to the removal of very fine droplets. Larger oil droplets lesser than 100 μm are removed from secondary emulsions using coalescence bed filters, which are made of either fibrous or granular packing. Fibrous media have greater surface areas and porosities than coarse granular media, which results in greater oil removal effectiveness. It is critical to comprehend the method of oil separation to develop a fibre coalescence bed filter that treats industrial discharge effectively. Regarding surface chemistry and roughness, this relates to the wettability of fibres surfaces.

Furthermore, porosity, bed height, pore size, and fibre diameter in relation to influent oil concentration and droplet size are interaction characteristics that influence the effectiveness of coalescence. Coalescence filtering performance is assessed using the oil concentrations and D50 (median value of droplet sizes at 50% in the cumulative distribution) droplet sizes in the influent and effluent. In this investigation, a non-ionic surfactant was used to create a stable emulsion of engine oil in water at a concentration of 10%. As filter beds, kapok fibres were utilised to separate the oil from the oil-water emulsion. SEM analysis was employed to study the surface morphology of fibres, and Fourier transform infrared (FTIR) analysis to investigate the chemical bonding of fibres. For the coalescence filter, three different bed heights (10 mm, 20 mm, and 30 mm) and four different porosities (0.90, 0.92, 0.95, and 0.98) were used to create kapok filter beds. The filter column was pumped with the oil-water emulsion (influent). The effectiveness of the oil separation process was assessed in terms of the droplet size (D50) change and oil concentration from influent to effluent. Apart from a porosity of 0.92, the separation efficiency increases with the increases in porosity and bed height. At lower

porosities, raising the bed height has no positive impact on the process efficiency. The highest filtration performance in terms of oil separation efficiency and D50 droplet ratio was achieved with 0.98 porosity and a bed height of 30 mm. When the bed height was increased from 10 to 30 mm at 0.98 porosity, the D50 droplet ratio decreased from 0.25 to 0.14, indicating a considerable reduction in the size of the droplets in the effluent and, consequently, an enhances the oil separation efficiency from 91.3 to 99.63 %.

Further, coalescence filters were prepared using milkweed fibres for oil separation from oil-water emulsion. The chemical groups, microstructure, morphology, and surface hydrophobicity of the fibres were analysed using FTIR, SEM, and contact angle techniques, respectively. A non-ionic surfactant was used to create a stable emulsion of engine oil in water. Deep bed coalescence filters were constructed at three filter bed heights (10 mm, 20 mm, and 30 mm) with a combination of three porosities (0.92, 0.95, and 0.98). Maximum filtration performance in terms of oil separation efficiency (99.73%) and D50 droplet ratio was achieved at a porosity value of 0.98 and bed height of 30 mm. Fouling was not observed while continuously operating the filter bed having 30 mm depth and 0.98 porosity for a long duration.

We investigated coalescence filtering on a bed produced from kapok and milkweed fibres and how they separated oil from emulsions at different porosities and bed heights. The ability of filter beds to separate oil improves with the increases in porosity and bed height. The filter bed with lower porosity saturates more oil in the bed. Increasing the bed height at lower porosity (0.92) could not significantly improve the oil separation efficiency, as the high-pressure drop eject the larger droplets into the effluent, coupled with fewer available fibre surfaces for the coalescence to take place effectively. The potential for using kapok and milkweed filters to coalesce fine oil droplets in stable oily emulsions is significant. The separation efficiency for kapok and milkweed filter beds of up to 89.6% and 93%, respectively was achieved at a porosity of 0.98 and bed height of 30 mm. The lower amount of oil in the influent shows a

higher separation efficiency because the filter bed retained most of the oil in its structure. The smaller size of the droplets (2 μm) makes it difficult for them to stick together inside the structure or intra-fibre pores. In this case, the separation efficiency decreases with the increase in porosity and bed height. When the droplets are 2 μm in size rather than 5 μm in size, the oil separation efficiency of kapok and milkweed filters is reduced.

Recently, there has been a lot of interest in using natural materials that can absorb a lot of oil as sorbents to clean up oil spills in seawater. Therefore, we developed a nonwoven sorbent; by utilizing a carding and needle-punching process, kapok fibres were combined in various ratios with cotton fibres received as blow room waste from the textile industry. We investigated the potential of kapok/waste cotton nonwovens for oil sorption, oil retention, and water sorption. Since the physical and chemical characteristics of the fibres affect their ability to absorb oil, FTIR, SEM, and surface contact angle measurements were performed. The behaviour of a nonwoven made of kapok and waste cotton about oil absorption and oil retention was investigated. Blended nonwovens (kapok/cotton, 90/10) having an areal density of 150 GSM or g/m^2 exhibited maximum oil sorption capacities of 45.36 g/g , 43.97 g/g , and 39.92 g/g for engine oil, vegetable oil, and diesel oil, respectively. According to the findings of the reusability test, the oil absorbency of 150K/C 90/10 against engine oil, vegetable oil, and diesel oil was 42.55 g/g , 40.61 g/g , and 36.45 g/g , respectively, after ten cycles. A comparison of the kapok/waste cotton blends to absorb oil with that of other synthetic (Polypropylene) sorbents was also presented. Our research suggests that nonwovens made of waste cotton and kapok fibres could play a significant role in the cleanup of oil spills.

Finally, all significant findings discussed in earlier chapters are summarised, and the future scope of the research work is proposed.