SORPTION PROCESS USING POLYAMIDE NANOFIBRES TO REMOVE DYE FROM SIMULATED WASTEWATER

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Abstract:
The aim of this study was to examine the use of polyamide 6 nanofibers as a sorbent material for removal of dye on textile wastewater. Simulated wastewater of acid dyes (namely Colour Index Acid blue 41, Acid yellow 42 and C.I Acid blue 78) was used for experiment test with simulated concentration of 10 mg L\(^{-1}\), for sorption process electrospun polyamide 6 with areal weight 12 g m\(^{-2}\) was used as the sorbent material and the process was performed under vacuum pressure. The experiments were realised in temperatures 20, 30, 40, 50 and 60°C. The experimental result showed that the presented study on polyamide 6 nanofibers has a great potential to be used for dye removal, since it was able to absorb dye at room temperature.

Key Words: sorption process; polyamide, nanofibers; wastewater; dye removal

1. INTRODUCTION
The extensive use of dyes in textiles, printing, dyeing, and food plants has produced a large amount of dye wastewater. Because some dyes and their degradation product may be carcinogen and toxic, the removal of dyes from wastewater becomes a vital issue in environmental protection \[1,2,3\]. Furthermore the presence of unfixed dyes in textile industry is perceived as one of the major environmental problems of textile wastewater, because colour is visible to the public even if the concentration is lower than other pollutants, which increases the need for it to be removed before it is discharged. \[3\] The treatment of dye effluent is rather not easy because of their synthetic origins and their mainly aromatic structure, which are biologically non degradable. This prevails on intensive search for the best available technology for the dye removal. Various physio-chemical methods have been put forward to satisfy the above requirement (such as advanced oxidation, biological process, coagulants, oxidizing agents, membrane, electrochemical, and sorption techniques). Amongst all these chemical and physical methods sorption process is one of the effective techniques that so far have been successfully employed for colour removal. \[1, 3, 4\] In this process various adsorbents (sorbents) have been examined to reduce dye concentrations from aqueous solutions. Activated carbon is regarded as effective however expensive adsorbent due to it high cost of manufacturing and generation, some others including peat, chitin, silica and some agriculture waste has also been utilized but sorption capacities of the above adsorbent are not very high. To improve efficiency of sorption process, it is necessary to develop cheap and easily available adsorbents with high sorption capacities \[4\]. Since extraction mainly relies on the holes of the surface of material and limited active groups ,this means chemical composition and morphology characteristic of the sorbent are the limits for the efficiency and sorption capacity, while available or currently used sorbents are normally micrometer-sized \[5,6\]. With this increasing demand on finding the best suitable sorbent, more attention has been paid to nanostructure materials represented by nanofibers. The high surface –to- volume ratio of nanostructure materials provides the numerous deal of active site for sorption, making a foundation for efficient separation, extraction and enrichment. \[5\] Furthermore there has been a great interest on research and development of nanofibers in recent years due to the heightening awareness of it potential in medical and engineering applications. \[8\] The widely accepted technique to fabricate submicron polymer fibers to engineer unique functional
nanostructure is electrospinning. [7, 6] The electrospinning process is a fiber forming process, where high voltage is used to create an electrically charged jet of polymer solution or melt from the needle. [7] Nanofibers have a strong penetrability and interaction with other compounds, which make sorption more superior, and due to their high porosities and interconnected pore structure offer a high permeability to water filtration over conventional used materials. [8, 5, 10] When nanofibers are compared to macro scale adsorbents electrospun nanofibers own a high surface-to-volume ration and length to the diameter ration that can provide a larger specific surface and more active sites for sorption: accordingly the attachment of the target molecules would facilitate and a small amount of nanofibers is adequate for the extraction, which greatly reduces the volume of desorption solvent. [9] In this study polyamide 6 electrospun nanofibers were used as the sorbent material to study the sorption-filtration process of simulated solution of dye wastewater. Blue acid dye was chosen as the target sorbate on the simulated wastewater for textile industry due to their high affinity to polyamides. Important parameters were calculated which define the capability of substrate.

2. Experimental

The electrospun polyamide 6 nanofibre membrane that was used as a sorbent during sorption nanofiltration was purchased from the company Elmarco s.r.o (Czech Republic), with the areal density of 12g.m\(^{-2}\) (fig. 1). The pieces of 30 mm x 30 mm were used for all the experiment such that the whole radial surface could fit within the dimensions of each piece.

![Fig 1: Used polyamide nanofibres](image)

The filtration unit that was used was the normal unit used for membrane filtration for laboratory scales. The sorption – filtration process (fig. 2) was performed under vacuum pressure created by suction pump where the vacuum flask was used to collect the filtered sample and the volume used per each cycle was 10 ml, test tubes were used to store the filtered samples. For testing the sorption capacity of the electrospun polyamide 6 nanofibers the spectrophotometer was used to measure the initial concentration of unfiltered sample and also the final concentration of filtered sample. Acid dyes were used because of their high affinity to polyamide.
3. RESULTS AND DISCUSSION

Below are the graphical presentations that show the relationship between accumulated mass of dye, change in mass of dye and also the concentration after filtration all against the number of runs in order to reflect the effect of the temperature on filtration during the investigation. The following graph gives the summary of the effect of increasing temperature on the amount of dye that is accumulated on the membrane, it is an overview of the total effect of all the temperature used, also reflects the behaviour of the accumulation of dye at each temperature.

**Fig 3**: Accumulated mass of dye (C.I. Acid Blue 41) as a function of number of dyeing cycles

**Fig 4**: Accumulated mass of dye (C.I. Acid Blue 78) as a function of number of dyeing cycles
4. CONCLUSION

In conclusion, after the analysis of results of the determination of temperature effects on sorption using three dyes, it was obtained that C.I Acid Blue 41 solution had a high percentage of dye removal, or accumulated on the membrane, followed by C.I Acid Blue 78 and then lastly C.I Acid Yellow 42. This behaviour was observed in almost all temperatures during the study, from a temperature of 20 °C to 60 °C. These results were in good agreement with the molar masses of the dyes, C.I Acid blue 41 has the smallest molar mass, followed by C.I Acid blue 78 and lastly was C.I Acid Yellow 42. The molar mass values could be a good indication to reflect that there is an implication of the dye C.I Acid blue 41 having larger molecules or particles compared to the other two and also that dye C.I Acid yellow 42 had smallest particles than all other investigated dyes. All the figures (fig. 3 – fig. 6) showed that accumulated mass of the dye decreases as the temperature increases, till the temperature of about 40 °C such that at higher temperature there is a turn over point such that the accumulated mass is higher at 50 °C but below the one at 20°C. At the temperature of 60 °C, the accumulated mass was higher than all other temperatures. The reason for this was that above the glass transition temperatures of Polyamide 6 (47°C), there was swelling of the membrane making the pores even smaller for dyes to diffuse.
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