CIGARETTE BUTT-BASED POROUS MATERIALS FOR ADSORPTION/PHOTOCATALYSIS OF AQUATIC POLLUTANTS

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Introduction

Cigarette butts when inadequately disposed pose a serious pollution hazard to the environment[1]. A solution to this environmental problem can be the use of cigarette filters as raw materials for the development of low-cost porous materials. Moreover, their application for water treatment purposes can promote a cyclic economy format. The aim of this work was to synthesize chars and membranes from cigarette filters, providing a viable disposal solution for cigarette butts and to elucidate the materials potential for adsorption/degradation of pollutants commonly detected in the aquatic environment.

Materials and Methods

Cigarette butts were collected, the filters separated and cutted into cylinders (0.5 cm thick). The carbonization of fresh (UC) and smoked (SC) filters occurred under N_2 flow, at 650 and 900 °C, for 2 h. The chars were named according to Filter type(pyrolysis temperature-pyrolysis duration) (e.g. UC(650-2)). Membranes were prepared by dissolving 2 g of filters in 10 cm^3 of acetone and NaCl, and glycerol (3 cm^3) were added. NaCl:filters weight ratios of 0, 1:6 and 1:7, were used. The final mixture was poured onto a petri dish until complete drying, and washed with HCl and distilled water. Selected membranes were carbonized at 200 °C (1h), under N_2 flow. The membranes were designated: NaCl:Filters ratio Filter type, and the carbon membranes: NaCl:Filters ratio Filter type(carbonization temperature(°C) – duration of pyrolysis(h)) (e.g. 1:6 SC and 1:6 SC(200-1), respectively). The chars were characterized by N_2 adsorption at -196 °C, and pH_{PZC} measurements, and the membranes morphology, porosity and surface chemistry was investigated by scanning electron microscopy (SEM), water porosity and pH_{PZC} measurements, respectively.

Results and Discussion

Chars were obtained with average yields of 12 % (UC) and 17 % (SC) (Table 1). Developed porosities were attained, composed exclusively by wide pores (mesopores and supermicropores). More advantageous textural properties were achieved at 650 °C, and the presence of tobacco additives led to higher porosity in char SC(900-2), which can be explained by formation of reactive species during cracking of the tobacco contaminants. Higher aromaticity in UC(900-2) led to an increase in pH_{PZC} value, and thermal cracking of tars in SC samples caused the formation of basic functionalities. Chars doped with hematite and silica are currently being prepared to assess the potential of the samples for catalytic purposes. The membranes for example, 1:6 UC, contains pores created by NaCl solid (average width 0.68 μm), and wider pores created by solvent evaporation (widths higher than 1.5 μm) (Figure 1(a)). Membranes with overall porosities between

32 and 74 % were prepared (Figure 1(b)). Increase in NaCl amount caused significant increase in porosity and, the intercalation of tobacco contaminants during synthesis led to membranes with lower porosities. No difference in porosity was observed in 1:7 SC membrane, after carbonization, even though pore size uniformization was confirmed by SEM analysis (data not shown).

Table 1. Preparation yields and nanotextural properties of the chars.

	η^a (%)	A_{BET} ($m^2 g^{-1}$)	V_{total}^b ($cm^3 g^{-1}$)	V_{meso}^c ($cm^3 g^{-1}$)	V_{micro} ($cm^3 g^{-1}$)	V_{ultra} ($cm^3 g^{-1}$)	V_{super} ($cm^3 g^{-1}$)	pH_{PZC}
UC(650-2)	11	530	0.30	0.10	0.20	0.00	0.20	6.2
UC(900-2)	13	145	0.16	0.13	0.03	0.00	0.03	9.1
SC(650-2)	16	494	0.35	0.17	0.18	0.00	0.18	9.4
SC(900-2)	17	418	0.31	0.16	0.15	0.00	0.15	9.4

[a]Preparation yield; [b]N_2 volume adsorbed at $p/p^0 = 0.95$; [c]$V_{meso} = V_{total} - V_{micro}$.

In UC membranes, a correlation between porosity and pH_{PZC} was observed (pH_{PZC} 1:6 UC (4.3) *vs* 1:7 UC (8.3)) (Figure 1(c)). SC samples are basic in nature and no correlation between porosity and pH_{PZC} is observed. An increase in aromaticity yielded a more basic surface in 1:7 SC(200-1) char. Preliminary kinetic adsorption data concerning clofibric acid adsorption, pointed out the potential adsorptive properties of the samples, for example, SC(650-2) adsorbed approximately 50 mg dm^{-3} of pollutant after 4 h of contact time.

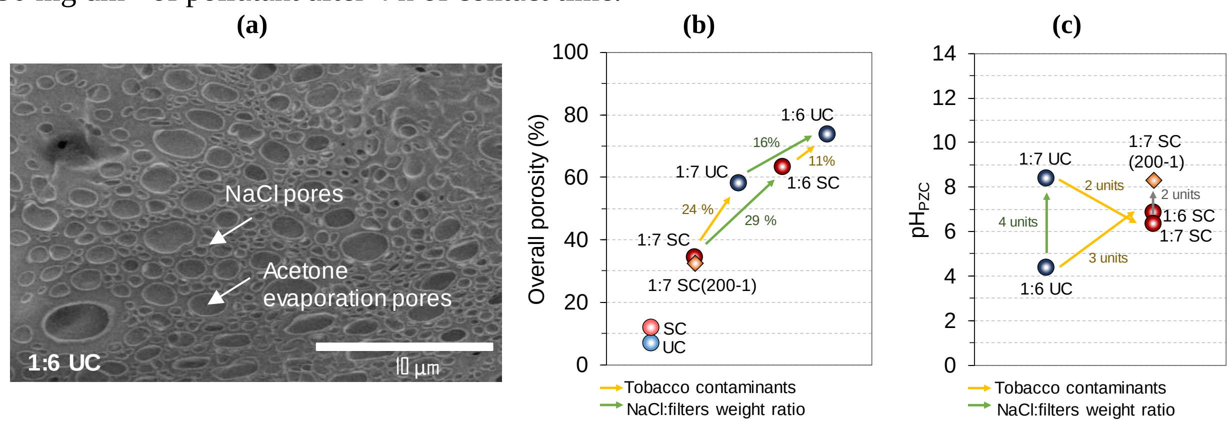

Figure 1. (a) SEM micrograph of 1:6 UC membrane, and (b) water porosity and (c) pH_{PZC} measurements. UC, SC - fresh and smoked filters dissolved in acetone.

Conclusions

The use of smoked cigarette filters as raw materials for the synthesis of chars and membranes is a viable solution for the cigarette butt pollution scenario. Porous materials (chars and membranes) were successfully prepared *via* simple synthesis procedures. Liquid phase adsorption studies will continue and the catalytic potential of the materials investigated.

Acknowledgment

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References

1. Kadir, A.A., Sarani, N.A., (2015). Cigarette butts pollution and environmental impact – A review. *Appl Mech Mater* 773-774, 1106-1110.