NANOSTRUCTURED CARBON ADSORBENTS FOR HAEMOPERFUSION

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INTRODUCTION.

500 million persons live with various kidney diseases. Chronic illness of kidneys eventually leads to the terminal stage known as end stage renal disease (ESRD). Dialysis is a life sustaining therapy for patients who progress to ESRD and do not receive a transplant. There are over one million ESRD patients on dialysis worldwide. Despite the relatively high cost of dialysis ($55,000 per patient per year) patient survival remains poor. Current dialysis systems remove small, water soluble metabolites but fail to remove significant amounts of higher molecular weight and protein bound uraemic toxins whose retention is most damaging. In this project an alternative extracorporeal treatment using adsorption as the main clearing process, is being developed.

MATERIALS AND METHODS.

Physicochemical properties of granulated activated carbon (AC) produced from rice husk (RH-AC, Fig. 1) and AC monoliths produced from rice husk using lignin binder (Fig. 2) were investigated. The adsorption characteristics of the carbon monoliths prepared from rice husk were assessed for their adsorptive capacity for a range of biological toxins in a recirculation system using fresh frozen human plasma to mimic the process of haemoperfusion in the clinic. An enzyme linked immunoadsorbent assay (ELISA) was used to determine the concentration of the inflammatory cytokines TNF, IL-6 and IL-8 in the plasma samples.

RESULTS AND DISCUSSION.

The preliminary study of the pore structure of AC monoliths produced from rice husk with lignin binder, has demonstrated that they show some mesoporosity below 10 nm in diameter, but the majority of the porosity is comprised of micropores of a much smaller size, whereas powder AC produced from rice husk without using a binder, has larger contribution of mesopores to its porosity. The initial investigation of the monoliths in a flow through system confirmed these findings, as they showed poor removal of the larger molecules of TNF (molecular mass 52 kDa) and IL-6 (21-28 kDa), with better elimination rate of the smallest IL-8 molecules (6-8 kDa). The powder AC had higher adsorption efficiency towards all three target solutes. Further work should focus on transferring the mesoporosity inherent to the rice husk AC powder into the monoliths, with the aim of improving the removal of the biological toxins of interest with higher molecular mass.

CONCLUSIONS.

The adsorption profile for the cytokines TNF, IL-6 and IL-8 revealed that the monoliths were able to remove clinically relevant levels from blood, although the removal of TNF was more challenging. These results suggest that using carbon monoliths in a haemoadsorption device could provide a potential therapy for reducing high levels of inflammatory cytokines in the blood of patients suffering from such severe conditions as multi-organ failure, systemic inflammatory response syndrome and sepsis.

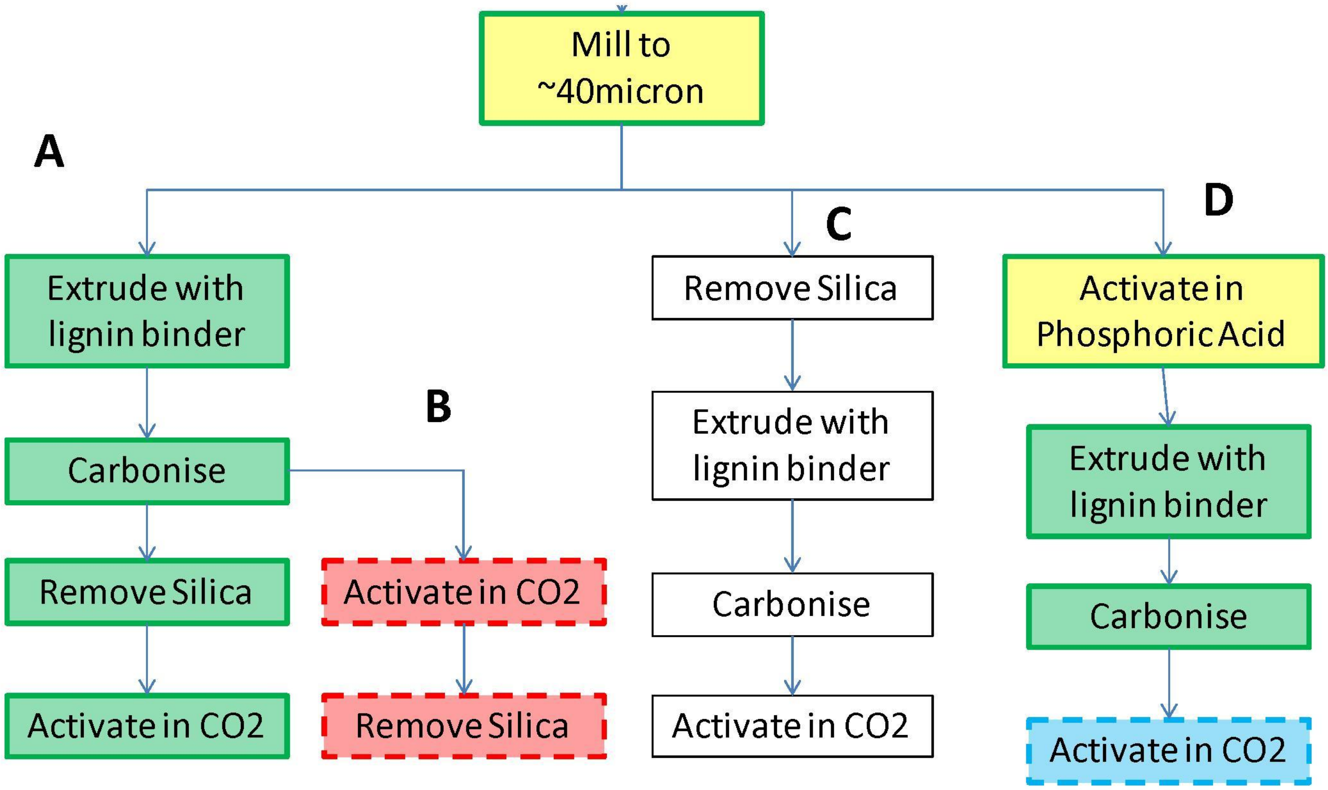

Figure 1. *Manufacturing of activated carbon from rice husk raw material.*

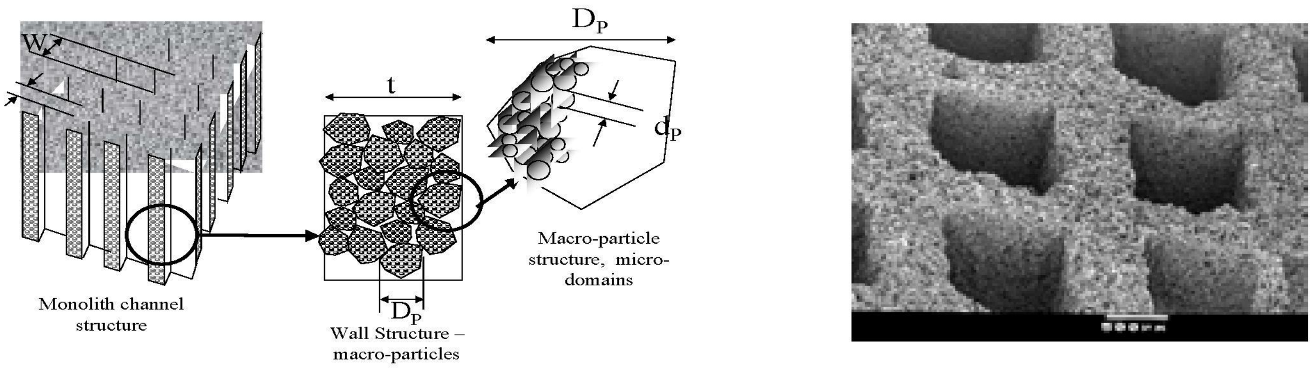

Figure 2. *Structure of carbon monoliths.*

Monolith channel size (t) and wall thickness (W): 30-60% open area, >1000 cpi; macrostructure of the channel wall, 20-60% porosity, macropore size 2-20 mm, particle size 10-70 mm. Micro- structure is fixed by lignin binder, nano domains ~10nm, micropore size 0.8 nm, surface area >1400 m^2. Internal and external mass transfer and tortuosity are adjustable.

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