



Carbon-based Materials for Extracting Urea to Recycle Waste Water in Space Applications



Chuong Vu, Eduardo Nicolau ², Tra-my Justine Richardson ¹, Carlos R. Cabrera ² and Michael Flynn ^{1*}

¹NASA Ames Research Center, Bioengineering Branch, Moffett Field, California 94036 USA

²University of Puerto Rico-Rio Piedras Campus PO Box 23346 San Juan, Puerto Rico 00936 USA

Abstract

Recycling waste water to potable water is necessary for long term space missions and applications. Previous experiments showed that urea, which is the main substance in urine, prematurely fouled the membrane used in the water treatment process. In this experiment we investigated different carbon-based materials to act as a urea pre-treatment step (fig. 1 urea fuel cell). A total of nine materials were tested for the amount of urea they can adsorb. The adsorption rate will enable us to decide which material is best for the pre-treatment process. Three out of nine adsorbents had 90% urea adsorption rate.

Background

Figure 1: Diagram of the Forward Osmosis/Reverse Osmosis (FO/RO) system use to recycle waste water. Part of the DOC system.

Figure 2: FO/RO unit of the DOC system.

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Materials

Adsorbent	BET Surface Area (m ² /g)	Micropore Diameter (Å)	SEM Image
Carbosieve SIII	975	4 – 11	
Carbosieve SII	1059	6 – 15	
Carbosieve G	1160	5 – 15	
Carboxen 563	510	7 – 10	
Carboxen 564	400	6 – 9	
Carboxen 1000	1200	10 – 12	
Carboxen 1016	75	N/A	
Activated Carbon	1800	Vary	
Oxidized Activated Carbon	Vary	Vary	

Method

- Weight 50 mg of materials
- Expose adsorbents to urea for two hours at room temperature
- Remove adsorbents as well as adsorbed urea
- QuantiChrom Urea Assay Kit (DIUR-500) used to measure unadsorbed urea

Results

Adsorbent	Adsorption capacity (molecules/cm ²)
Activated carbon	6.575 x 10 ¹⁵
Oxidized activated carbon	6.606 x 10 ¹⁵
Carboxen 563	2.326 x 10 ¹⁶

Figure 3: Urea adsorption rate of each adsorbent

- Best adsorbent are activated carbon, carboxen 563, oxidized activated carbon
- About 93% to 97% of urea in contaminated water is adsorbed in two hours

Future Work

- Test adsorbent on real urine sample
- Test adsorbent for contact time
- Develop method to enclose urease enzyme for bioelectrochemical degradation of urea
- Maximize biofuel cell to create energy

Figure 4: Urea biofuel cell reactor

$$H_2N-CO-NH_2 + H_2O \xrightarrow{\text{urease}} NH_3 + H_2N-CO-OH$$

$$H_2N-CO-OH + H_2O \xrightarrow{\text{adsorbent}} NH_3 + H_2CO_3 [H_2O + CO_2]$$