One step synthesis of N-doped activated carbons derived from sustainable microalgae-NaAlg composites for CO_2 and CH_4 adsorption

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Abstract: N-doped porous carbons were obtained by using microalgae-sodium alginate (NaAlg) as renewable precursors due to the high nitrogen content of microalgae. By way of composition of microalgae and NaAlg, the tiny microalgae cells dispersed homogeneously inside the NaAlg and porous carbons with large specific surface areas over 1000 m^2/g were obtained by simply one step pyrolysis under N_2. The resulted porous carbons exhibited very high CO_2 adsorption capacity and CH_4 adsorption capacity which was much higher than commercial available coconut activated carbons (S_{BET} 1350 m^2/g).

Keywords: N-doped porous carbon; CO_2 adsorption; CH_4 adsorption.

1. Introduction

The capture and storage of CO_2 and the utilization of new and cleaner energy, such as CH_4, are of great significance. Porous carbons is a kind of highly efficient adsorbent, which can be used for CH_4 and CO_2 storage, has good application prospects in energy conservation and environmental remediation due to the impacts of CO_2 release. Particularly, porous carbon derived from biomass or naturally biological materials have been widely used due to the low cost, wide availability, environmental benignity and renewability.[1-5]

2. Experimental

Chorella, Isochrysis and Platymonas subcordiformis were composited with NaAlg. The resulted composite was placed in a quartz reactor inside a tube furnace. The whole pyrolysis process was carried out under N_2 flow. The activation process was first heated to the carbonization temperature at an appropriate residence time and then to the activation temperature at a appropriate residence time.

3. Results and discussion

Table 1 Surface area (S_{BET}, m^2/g) of porous carbons derived from NaAlg, microalgae and microalgae-NaAlg composites at different activation temperatures.

Sample	600 ℃	650 ℃	700 ℃	750 ℃	800 ℃
NaAlg	171	412	417	583	595
Chorella	30	32	24	32	65
C-NaAlg composite	129	346	514	642	684
Isochrysis	51	38	61	138	53
I-NaAlg composite	254	609	539	522	736
Platymonas subcordiformis	284	453	459	601	627
P-NaAlg composite	334	509	909	922	1032

By composition, a mutual promotion effect was found between microalgae and NaAlg that porous carbons derived from composites show much higher S_{BET} and S_{micro} than those from NaAlg and microalgae individually.

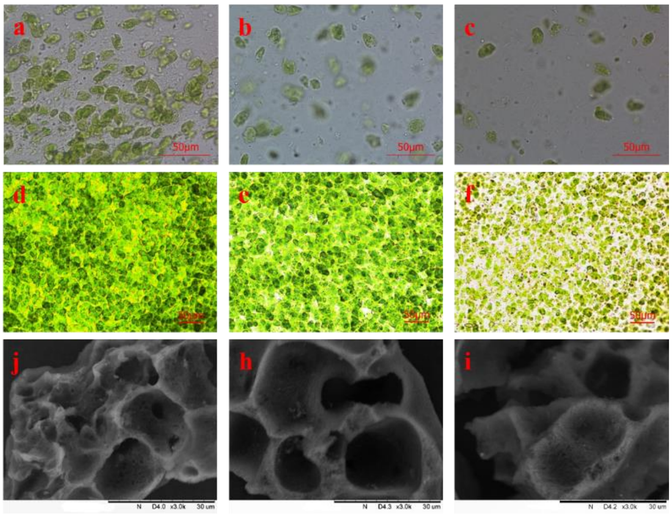

Figure 1. Microphotographs of P-NaAlg composites in the form of gel solution (a-c) and dry film (d-f). (j-i) SEM images of resulted porous carbons.

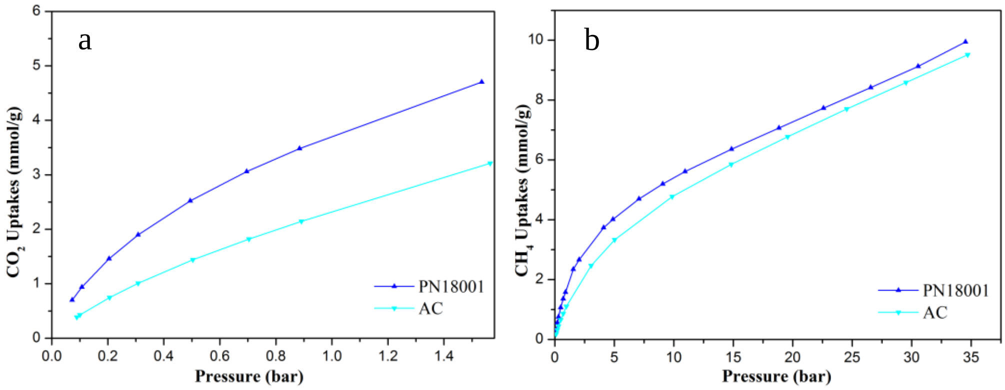

Figure 2. (a) CO_2 adsorption isotherms and (b) CH_4 adsorption isotherms of PN18001 and AC at 25 ℃. (a) the pressures up to 1.5 bar, and (b) the pressures up to 35 bar.

With high N content and appropriate pore size distributions, resulted porous carbons exhibited a very high CO_2 adsorption capacity of 3.75 mmol/g, 1 bar, 25 ^oC and CH_4 adsorption capacity of 9.95 mmol/g, 35 bar, 25 ^oC, which was much higher than commercial available coconut activated carbons (S_{BET} 1350 m^2/g).

4. Conclusions

Microalgae-NaAlg composites were initiatively used as sustainable precursors to obtain porous carbons with high CO_2 and CH_4 adsorption performance. Porous carbons were prepared by one simple carbonization process with flowing N_2 gas only and no any other chemical agents or gases was used. Sample PN18001 exhibited a high BET surface area of 1032 m^2/g. By composition, a mutual promotion effect was found between microalgae and NaAlg that porous carbons derived from composites show much higher S_{BET} and S_{micro} than those from NaAlg and microalgae individually. Sample PN18001 showed a very high CO_2 adsorption capacity of 3.75 mmol/g, 1 bar, 25 ^oC and CH_4 adsorption capacity of 9.95 mmol/g, 35 bar, and 25 ^oC. The results implied that abundant micropores, appropriate pore size distribution and high nitrogen content of porous carbons play very important roles in CO_2 and CH_4 adsorption besides high surface areas.

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