Selective Capture of CO_2 by Novel Microporous Hyper-crosslinked Aromatic-heterocyclic polymer

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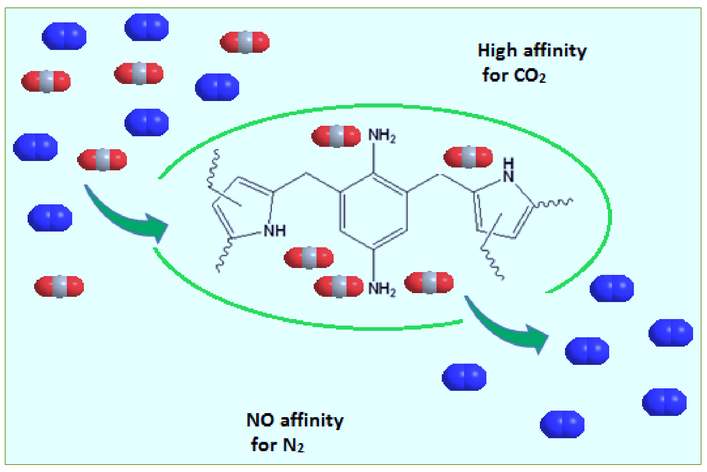
Abstract

A Novel class of hyper cross-linked microporous polymer (HCP) with excellent physiochemical properties was synthesized via one step polycondensation reaction of 1,4-diaminobenzene, paraformaldehyde and pyrrole (DAPY). The polymer was characterized via a variety of techniques. The unique properties of this polymer showed good capture of CO_2 with the uptake of 2.4 mmol g^{-1}, and selectivity of CO_2: N_2= 140: 1, and CO_2: CH_4 = 20:1, respectively. The excellent properties and selectivity toward CO_2 proves the efficacy of this polymer for selective capture and separation of CO_2 from post-combustion flue gas.

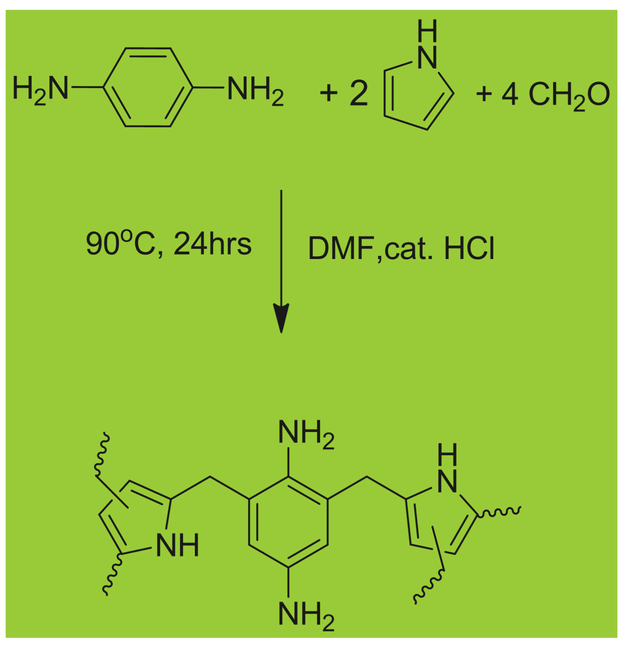


Motivation

Porous organic polymers are a very good candidate for selective CO_2 capture due to their properties that combine large specific surface areas, synthetic diversification and better physicochemical stability [1-4], organic polymers decorated with N_2 as CO_2 phallic functional group have a large impact for enhancing the CO_2 selectivity. This work seeks to address the challenge of capturing carbon dioxide gas that is generated from fossil fuel combustion processes. The primary objective is to design new materials that are capable of meeting the demands that carbon capture requires and ultimately, to produce new technologies that can be exploited for use in real-world applications.

Methodology

The polymer was synthesized by one step condensation reaction using HCl as activation agent for the formaldehyde.



Scheme 1: Schematic show synthesis route of benzene diamine-pyrrole hypercrosslinked polymer (DAPY)

Results

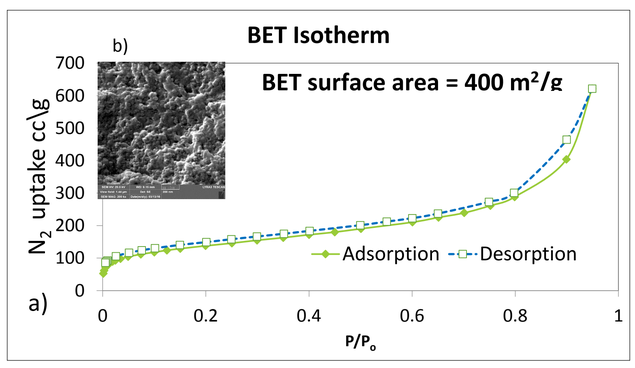


Figure 1: a) Nitrogen adsorption (closed)/desorption (open) isotherms at 77 K DAPY b) FE-SEM of the micropore DAPY polymer..

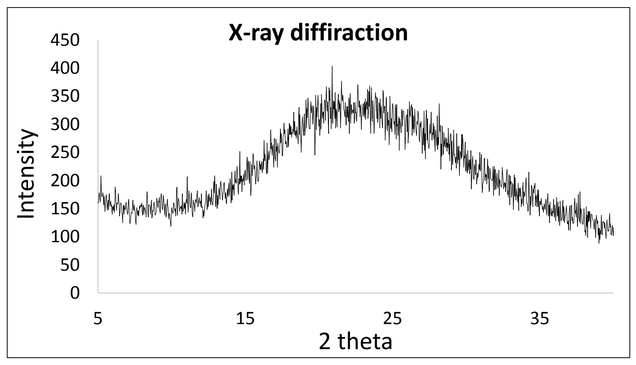


Figure 2: Powder X-ray diffraction of the DAPY polymer.

CO_2 measurements

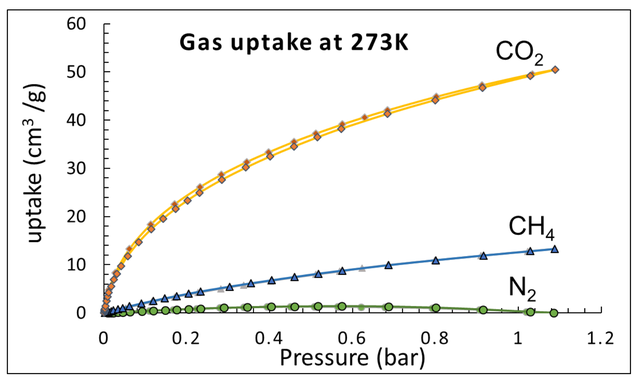


Figure 4: CO_2, CH_4, N_2 gas uptake of the DAPY polymer at temperature 273K.

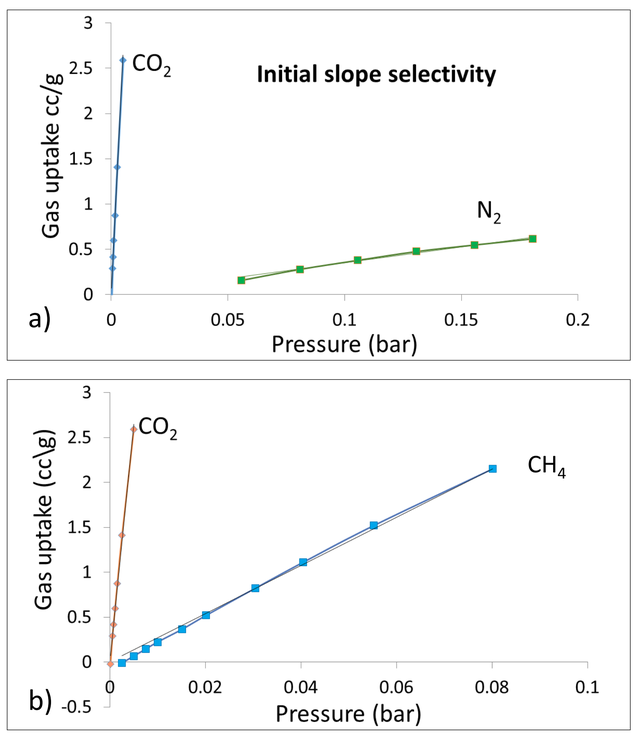
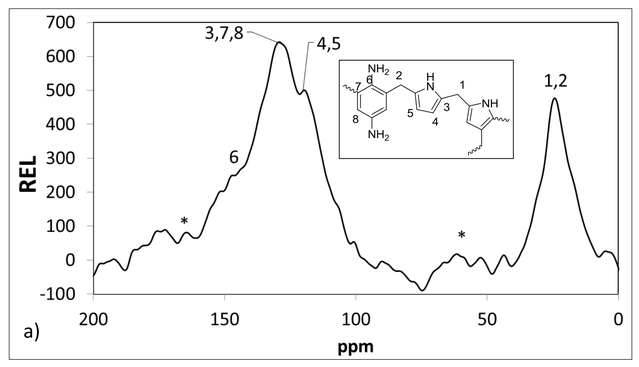


Figure 5: Selectivity of the DAPY polymer a) CO_2/N_2 and b) CO_2/CH_4



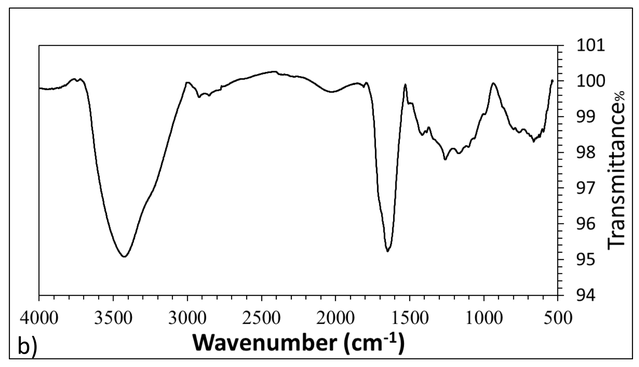


Figure 3: (a) Solid state ^{13}C NMR, b) FTIR of the synthesized DAPY polymer.

Sample	Condition	Selectivity	Year	Reference
DA/PY-HCP	273	140		This work
[TMPBI][Tf_2N]	273	7.1	2014	1
HCP-IL-8	273	47	2016	2
Th-1	273	39	2012	3
Py-1	273	117	2012	3
Fu-1	273	50	2012	3
APOP-1	273	23.8	2013	4
APOP-1-OH	273	35.1	2013	4
Glc-1	273	25	2015	5
Glc-2	273	39	2015	5
Glc-3	273	41	2015	5
NPC-650	273	23.4	2013	6
HCP-BA	273	28	2013	7

Table 1: Comparison of CO_2 uptake and selectivity of the synthesized PADY polymer with some of the reported organic polymers in literature.

Conclusion

- We have proved an easy and a straightforward way for the preparation of novel aromatic heterocycle-based porous polymer networks with accessible N_2 atoms for great affinity for CO_2.
- The polymer showed microporous nature with BET surface area of 400 m^2 g^{-1}. The unique properties of this polymer showed selective capture of CO_2 with the uptake of 2.4 mmol g^{-1}
- The polymer shows an extraordinarily high selective adsorption of CO_2 over N_2 (about 140: 1 at 273 K). To our knowledge, this selective CO_2 sorption is the highest among all the Hyper-crosslinked organic polymers reported to date.

Acknowledgment

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