Metal-Organic Framework/α-Alumina Composite with Novel Geometry for Enhanced Adsorptive Separation

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Overview

- Introduction on MOF/alumina composite
- Adsorptive separation study
  - Arsenic contaminated water remediation
- Discussion & Future work

Adsorptive Separation

• Industrial process for the purification of liquid or gas mixtures.

• Fixed & fluidized beds

• Drawbacks including:
  – 1) large pressure drop
  – 2) channelling of fluid
  – 3) break-up of adsorbent pellets

• Novel concept and design!
Metal Organic Framework (MOF)

• Definition:
  – “Inorganic metal ions or metal containing clusters” +“organic ligands”

• Unique features of this porous material:
  – large surface area & great porosity
  – customizable chemical functionalities
  – relatively mild synthesis conditions

• Applications:
  – adsorption, separation, sensing, catalysis, etc.

Zr-MOF UiO-66:
Zirconium oxide unit + BDC linker
UiO-66 Adsorbent

- Hydro-stable, even under acidic or some alkaline conditions

- UiO-66 for aquatic arsenic adsorption (Scientific Reports, 16613, 2015)
  - Wide pH working range (1-10)
  - Great thermodynamic capacity (303 mg/g)
  - Fast kinetic behaviour

- To be industrially applied => Binder problem?
α-Alumina

- Abundant supply in raw material & great resistance to various conditions

- Hollow fibre structure with novel geometry as advanced matrix
  - **micro-channels** serving as reaction chamber
  - **thin barrier layer** serving as sieve
MOF/α-Alumina Composite

Vacuum filtration method

Permeate water stream

Water stream with MOFs

Water stream with MOFs

Size-exclusion effect

Separation layer

Active MOFs deposited in micro-channels

Introduction (materials)  Performance Study  Discussion
MOF/α-alumina Composite for Arsenic Contaminated Water Remediation

Arsenic pollutant removal from water

• Arsenic contamination is a global threat due to its toxicity and carcinogenicity
• Arsenic concentration in most contaminated water ranges from 0.1 – 1 ppm.
• 1 ppm as the feed concentration
MOF/α-alumina Composite for Arsenic Contaminated Water Remediation

Introduction (materials)  Performance Study  Discussion
Inferior performance
• Random packing & non-ideal flow
• Even worse when limited amount of adsorbent were used
MOF/α-alumina Composite for Arsenic Contaminated Water Remediation

Alternative concept for adsorptive separation

- Micro-channels
  - adsorbent distribution
  - transport network (reduced mass transfer resistance)
  - more ideal flow
- Barrier layer
  - separation for suspended solids & micro-organisms

- Binder problem solved
- Module assembled
MOF/α-alumina Composite for Arsenic Contaminated Water Remediation

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Introduction (materials) Performance Study Discussion
Revisit Key Points

• MOF/α-alumina composite with novel geometry was developed for enhanced adsorptive separation

• The composite is able to produce potable water recovery from arsenic contaminated water

• To achieve a similar performance, the packed column bed required 8X amount of active UiO-66 adsorbents
Future Work

• More functional composites can be formed, based on the application purpose and the functionality of adsorbents

• Gas chromatography separation,
• Catalytic reaction,
• etc.
References & Acknowledgement

- Pictures used are adopted from Google Images without financial purposes.
- C. Wang, X. Liu, J. P. Chen and K. Li, Sci Rep, 2015, 5, 16613.
Thanks for Listening!!