Removal of As, Cd, Zn and Pb from aqueous solution by zeolite-like materials synthesized from MSWI Residues

Y.W. Chiang[1], B. Meesschaert[1,2], J. Martens[1], K. Ghyselbrecht[2], R. Santos[3], T. Van Gerven[3] , V. Cappuyns[4]
[1]Katholieke Universiteit Leuven, Department of Microbial and Molecular Systems (M²S)
[2]Katholieke Hogeschool Brugge-Oostende, Faculty of Industrial Engineering Sciences and Technology
[3]Katholieke Universiteit Leuven, Department of Chemical Engineering (CIT)
[4]Katholieke Universiteit Leuven, Department of Geology

ASSOCIATIE K.U.LEUVEN

SMART-PRO²
Sustainable Materialization of Residues from Thermal Processes into Products

Project Objectives

1. Development of a novel method to efficiently and inexpensively produce a bifunctional adsorbent from MSWI waste residues for:
   - SO_x/NO_x adsorption in flue gas cleaning; and
   - Heavy Metal adsorption in wastewater treatment.
2. Full utilization of 'in-house' materials (solids and gases) for the synthesis process.

Project Incentives

MSWI residue bottom ash is considered as hazardous material, it contains:

1. Fine Particular Matter
2. Heavy Metals (transition metals, Pb, Zn, Cd, As...)
3. Organic Compounds (Polychlorinated dibenodioxins, PCDD, Furans)

In current practice, the waste is generally stored in confined cavities in specific hazardous waste landfills (for example, French class I and II).

However, it is of great interest to the industry to turn this waste into useful products and valorization is an attractive alternative.

Main Advantages:

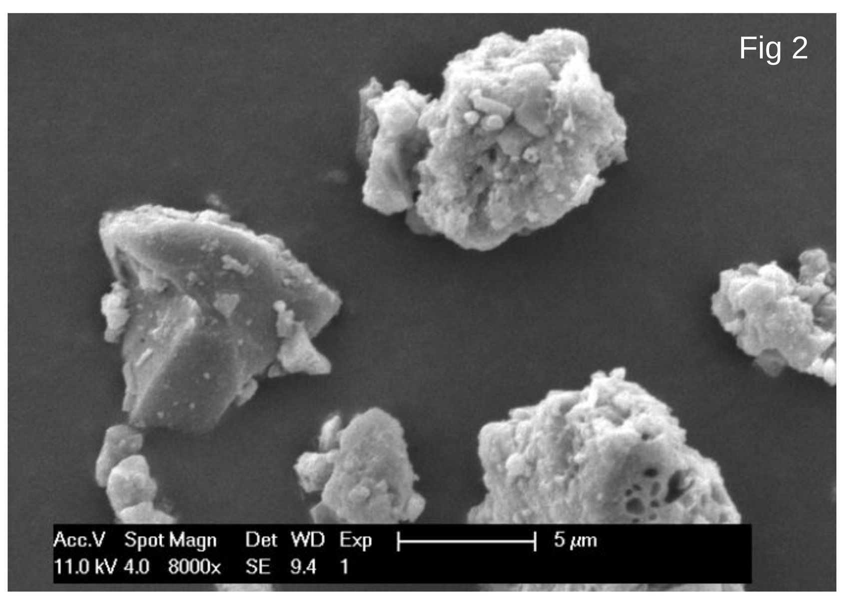
1. Hazardous waste disposal costs are minimized.
2. Less area is reserved for disposal at waste site.
3. Reduction in operating cost by replacing expensive gas cleaning and wastewater treatment agents.

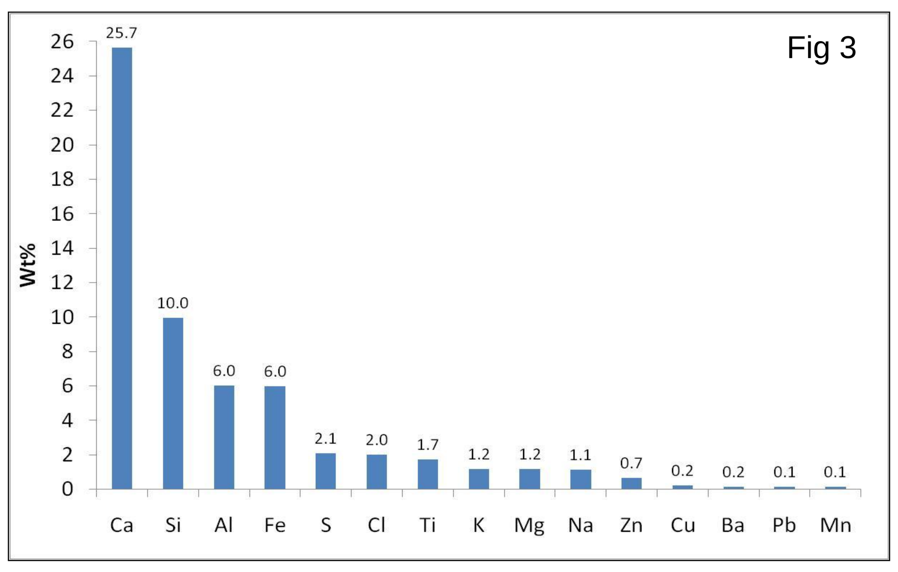
Theory and Chemistry

MSW incineration waste residues have great potentials for synthesis of low cost adsorbents due to its high Si/Al ratio, which is essential to the formation of mesoporous materials with high ion exchange capacity, high selectivity for polar molecules, and a large pore volume. They also exhibit an alkaline property which is a required precursor for the sol-gel synthesis reaction.

Previous experimental work have demonstrated the feasibility of these requirements, however, more research is required to solidify the proof-of-concept of the integrated process and identify the lowest-cost synthesis option.

Material Characterization





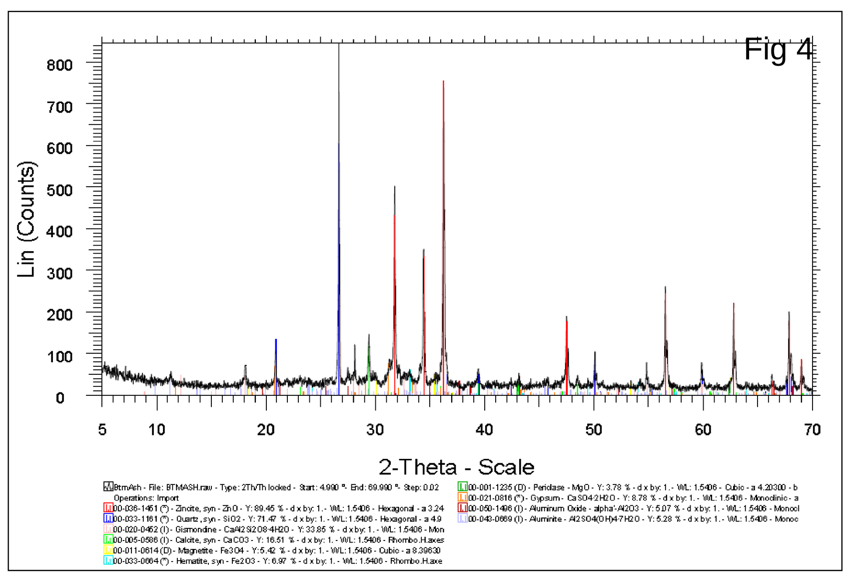
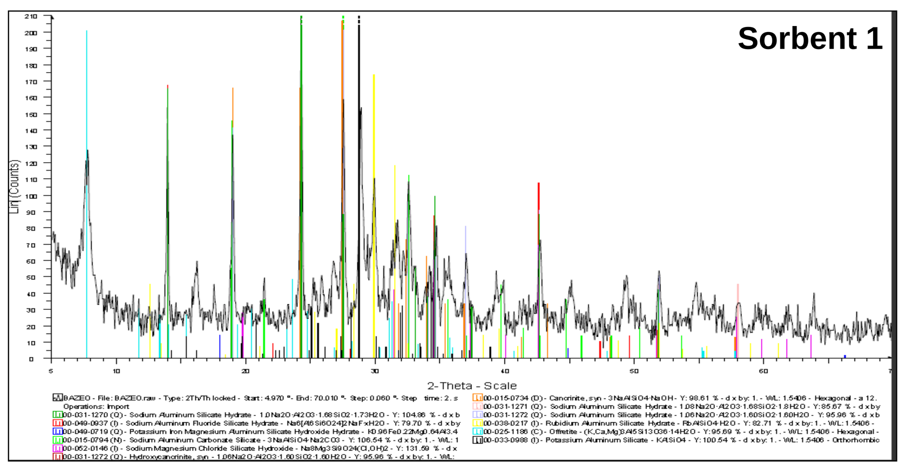


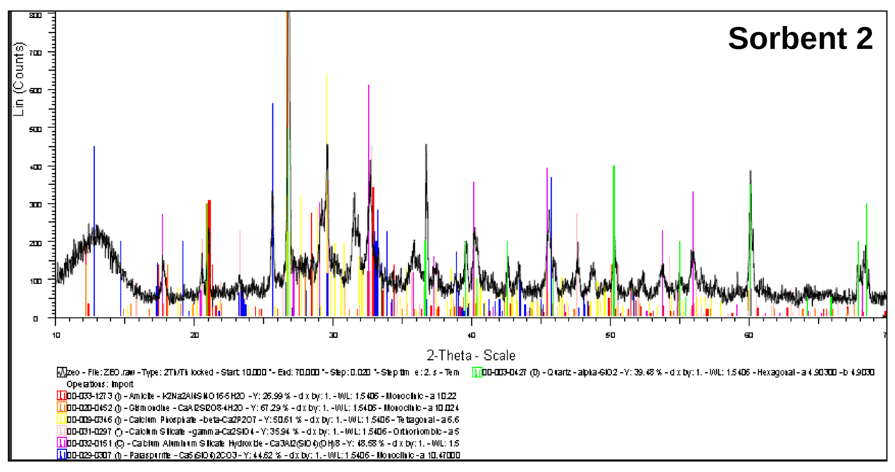
Fig 1. As received Bottom Ash
Fig 2. Scanning Electron Microscopy (SEM) for particle morphology;
Fig 3. X-ray fluorescence (XRF) and Inductively Coupled Plasma Mass Spectroscopy (ICP-MS) for chemical composition;
Fig 4. X-ray Diffraction (XRD) for mineral composition

Synthesis

Sorbent 1: Bottom Ash with caustic solution
3M NaOH, 150°C, 24 hours, L/S = 5

Sorbent 2: Bottom Ash with alkaline waste solution from MSWI
175°C, 48 hours, L/S = 5





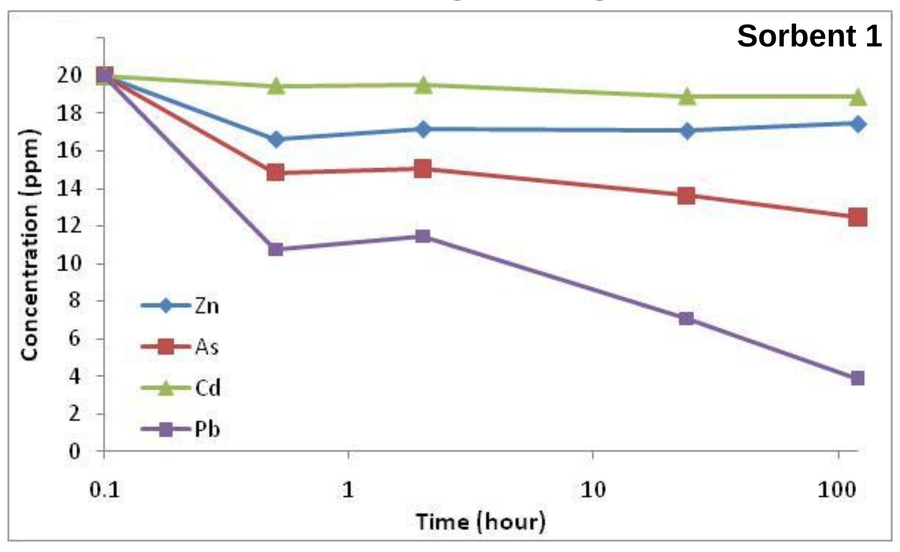
Synthetic minerals and zeolites:

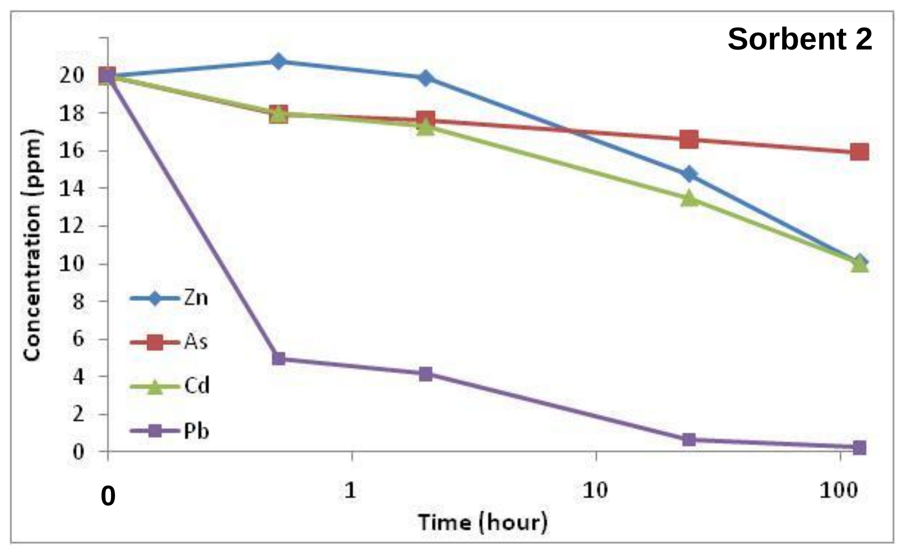
Sodium aluminum silicate hydrate:
$Na_2O \cdot Al_2O_3 \cdot 1.68SiO_2 \cdot 1.73H_2O$

Calcium aluminum silicate hydroxide:
$Ca_3Al_2(SiO_4)(OH)_8$
Amicite: $K_2Na_2Al_4Si_4O_{16} \cdot 5(H_2O)$
Gismondine: $CaAl_2Si_2O_8 \cdot 4(H_2O)$

Sorption Kinetics

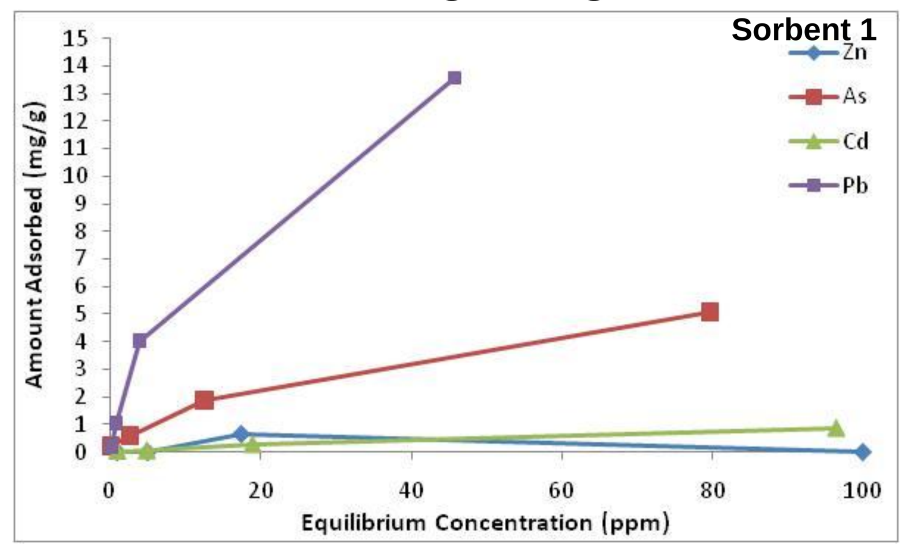
- Constant pH 5
- Initial concentration 20ppm (Zn, As, Cd, Pb)
- Sorbent dosage: 4 g/l

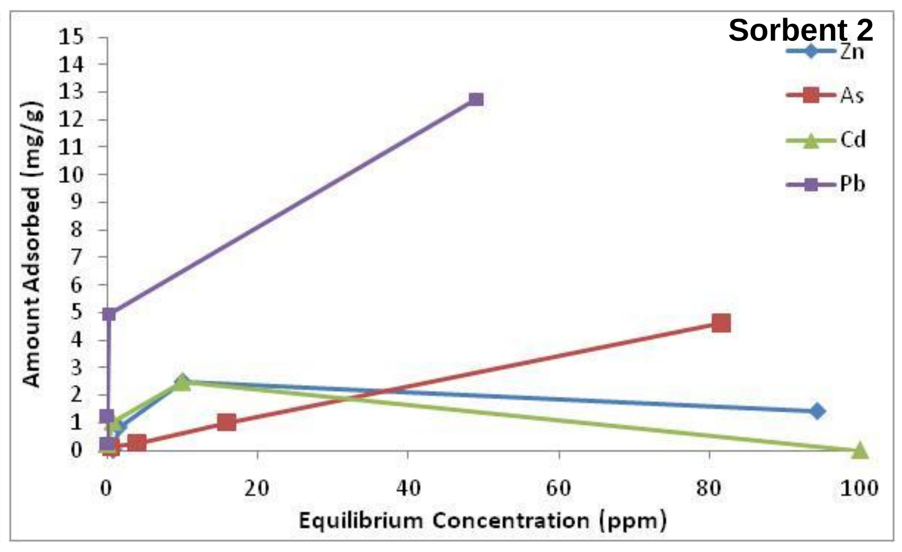




Sorption Isotherm

- Constant pH 5
- Initial concentrations 1, 5, 20, 100 ppm (Zn, As, Cd, Pb)
- Sorbent dosage: 4 g/l





Conclusions

- ✓ Competitive adsorption leads to preferred capture of Pb over other cations (Zn and Cd).
- ✓ Adsorption versatility confirmed by simultaneous adsorption of cations and oxianions (As).
- ✓ Adsorption capacity competitive with pure sorbents considering sorbent/zeolite content of treated waste material well below 100%.

Future Work

- Assessment of adsorption performance on single contaminants.
- Refinement of adsorption performance at lower contaminant concentrations (<1 ppm), more relevant to industrial/remediation applications.
- Optimization of synthesis conditions (additives, temperature, time, particle size) and quantification of synthetic sorbent yields.
- Expansion to flue gas treatment applications (SO_2, Cl_2, NO_x).

Contact

Kasteelpark Arenberg 23 - bus 2461, 3001 Heverlee, Belgium
YiWai.Chiang@biw.kuleuven.be
http://smartpro2.eu

Second International Slag Valorisation Symposium
18-20 April 2011 | Leuven, Belgium