ALBEMARLE® | Environmental Division

Innovative, One-Step Production of Albemarle's Concrete-Friendly™ Activated Carbon

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McIlvaine Company Hot Topic Hour
Mercury Control and Removal Status and cost

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Hg Control with Fly Ash Preservation

- **Class C coal fly ash ideal for concrete use (Pozzolanic)**
  - 11.5 million tons used in concrete market (2008)
  - Economic benefit
    - ✓ sale of fly ash, partially replacing costly cement
  - Environmental benefit:
    - ✓ Reduced land disposal, reduced virgin resource use, reduce GHG

- **Activated carbon Hg control increases fly ash carbon**
  - Air-entraining admixtures (AEA): create concrete air bubbles; improve freeze-thaw capabilities
  - Carbon adsorbs AEA
  - Need concrete compatible carbon or post treatment of carbon/fly ash

Fly Ash Preservation
Post-Treatment Techniques

- **Post-treatment of fly ash/carbon with ozone**
  - O_3 passivizes the carbon by creating O_2 surface groups; suppressing AEA adsorption; treats LOI as well
  - Requires an additional, costly step of treating large amounts of fly ash
  - Hurt et al. (2000); Chen et al. (2003)
  - Can be applied to only activated carbon (Nelson, 2003)

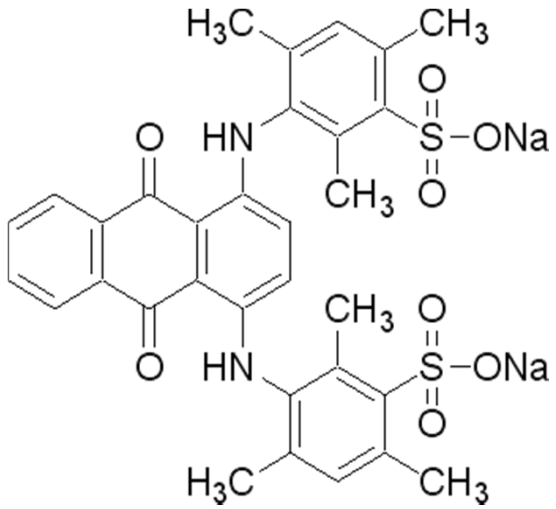
- **Addition of a "sacrificial agent" to concrete mix**
  - Carbon adsorbs the agent and not AEA thru a change in carbon surface: Ethyleneglycophenylether (EGPE); Jolicoeur et al. (2009); costly chemical

- **Carbon burnout in fly ash/carbon mixture**
  - Fluidized bed reactor reaching 860 °F; treats LOI as well (PMI Ash Technologies; see the references)
  - Energy consumption is high

Albemarle's one-step production of Concrete-Friendly™ Activated Carbon

- **Development of an Innovative Metric to measure concrete friendliness (patent-pending)**
  - Traditional foam index method: titrate an AEA into fly ash/AC to obtain stable foam
    - Crude/inconsistent method, depends on type of AEA used and analyst judgment
  - Acid Blue 80 (AB80) index replacing foam index to determine concrete friendliness of activated carbon (an spectroscopic technique)
  - AB80: chemical structure/molecular size similar to AEA
  - ABI results very consistent for various carbons under wide range of conditions; foam index is not
  - Discovered a specific range of ABI that results in minimal adsorption of AEA; thus Concrete-Friendliness

AB80



Albemarle's one-step production of Concrete Friendly™ Activated Carbon (cont'd)

How to achieve the desired ABI

- Design of pore size distribution
- Selection of appropriate carbon substrates
- Influence carbon surface properties

Kiln activation of Concrete-Friendly™ AC (C-PAC™)

- Accurate control of time-temperature to impart desired micro- and meso-porosity
- Control of activation media to generate desired oxygenated surface functional groups
- Patent Pending (Zhang et al., 2010)

Proper design of activation results in the one-step production of C-PAC™

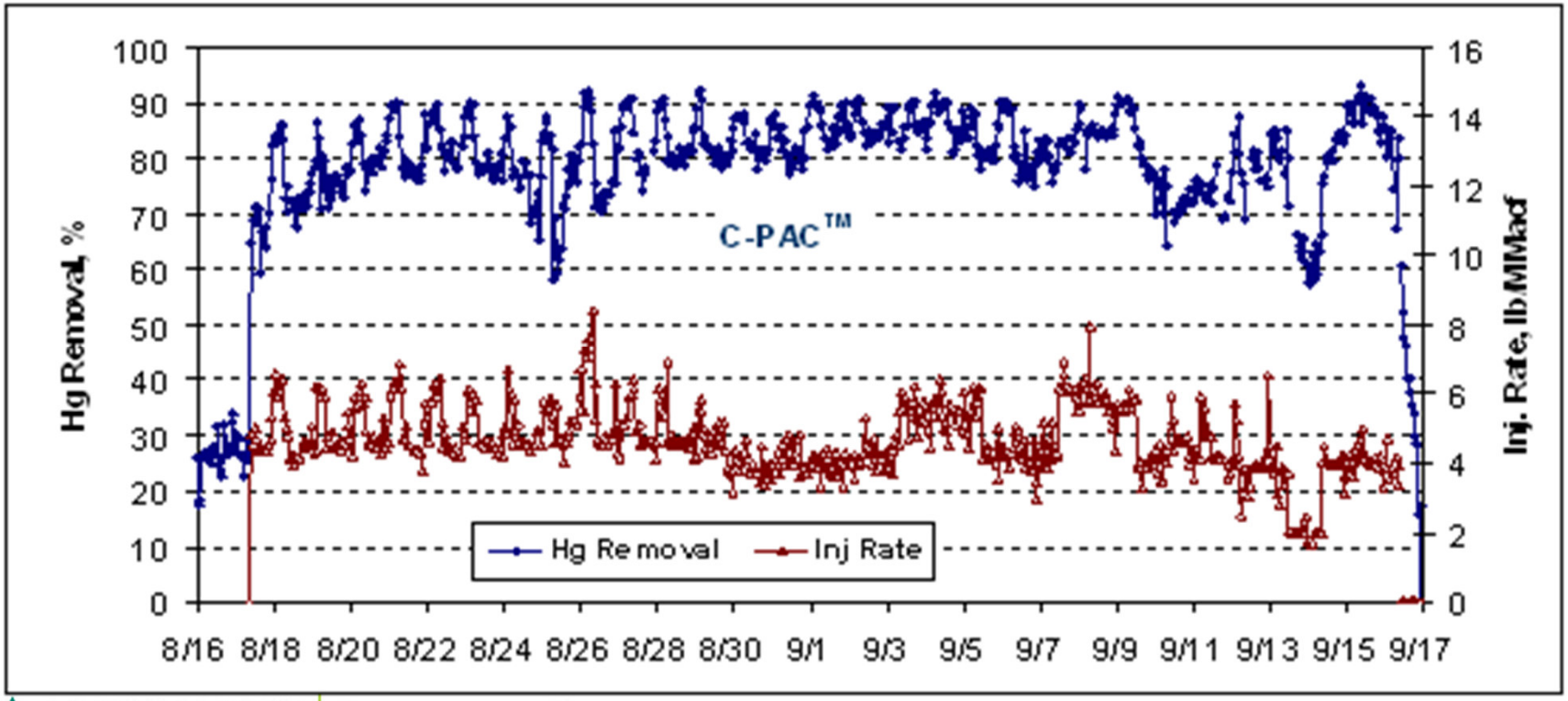
- No affinity for AEA
- Brominated, thus a very high affinity for Hg

C-PAC Hg removal performance

Testing at more than 14 full-scale power plants with different configurations; very high Hg removal

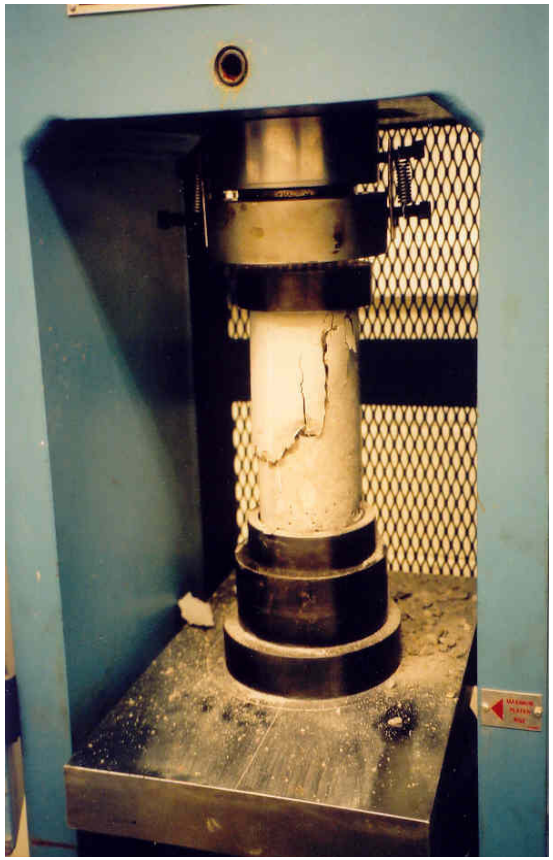
- Nelson et al., 2006; Zhang et al., 2010; Lipscomb, 2009; Nelson and Landreth, 2007, Zhou et al., 2007

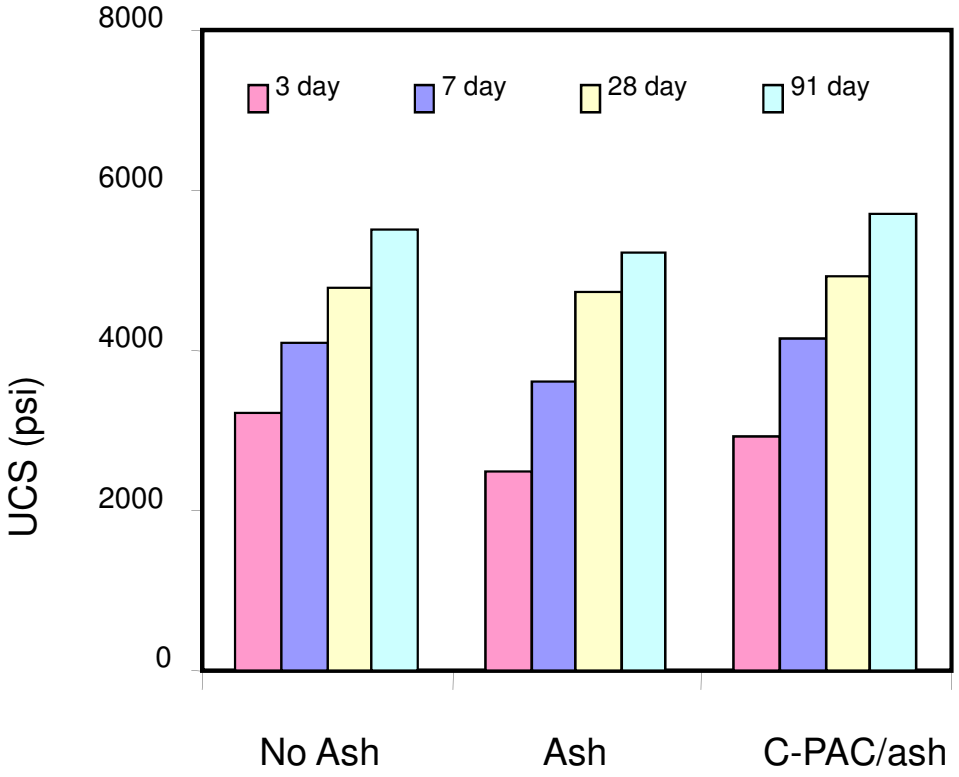
Midwest Generation's Crawford station; 234MWe, Subbit., C-ESP; Nelson and Landreth, 2007



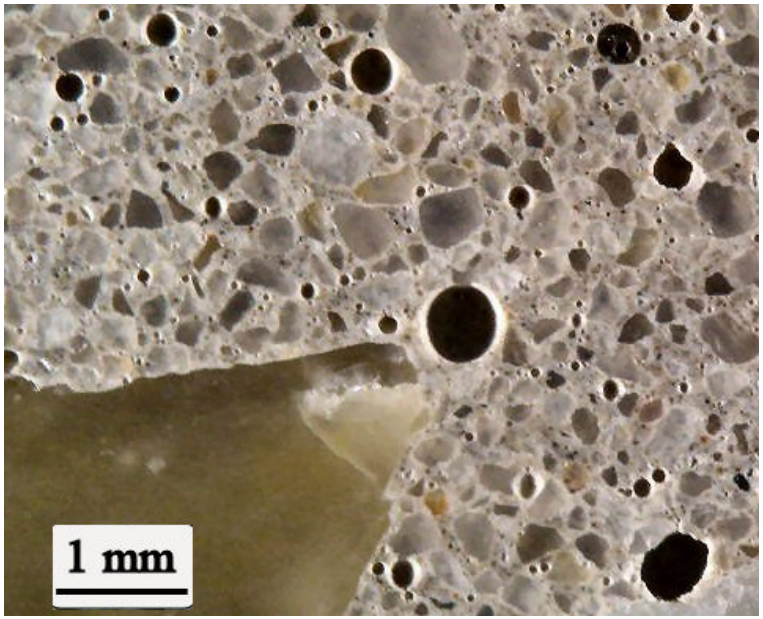
High comprehensive strength

Unconfined compressive strength (UCS): the capacity of the concrete to withstand axially directed compressive forces

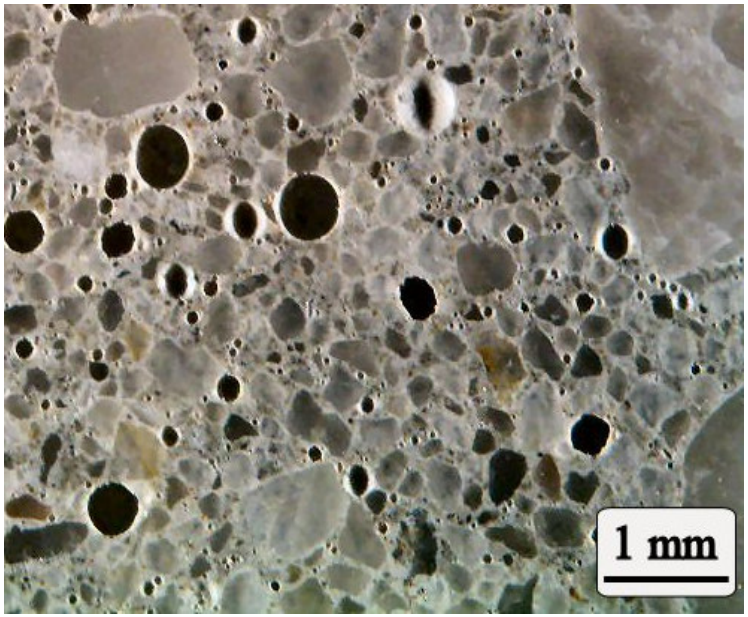




Air Content of Concrete



Concrete with baseline fly ash

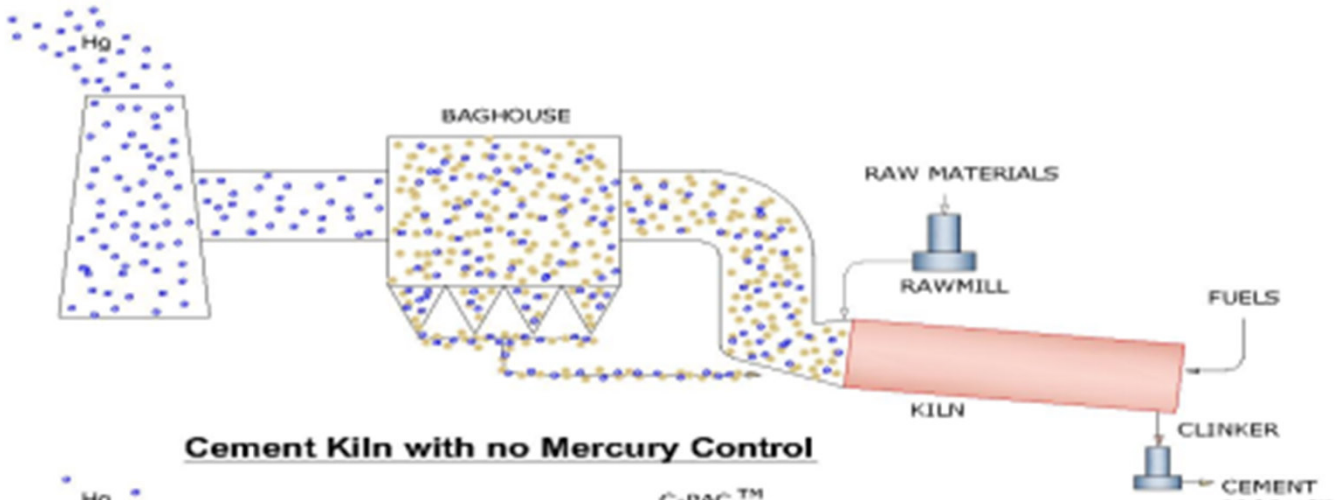


With C-PAC

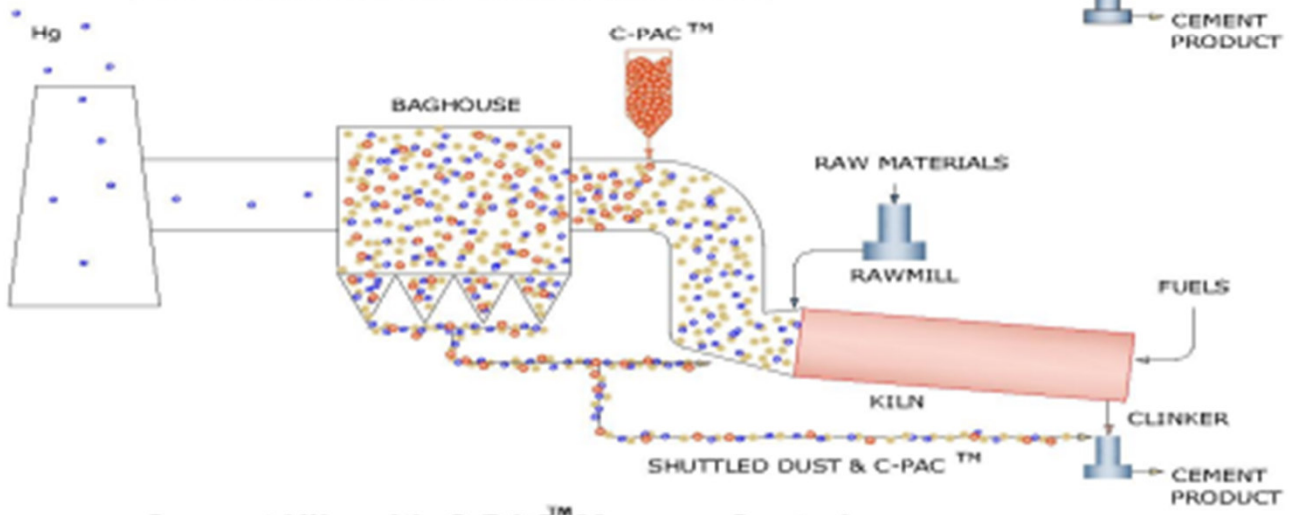
All foam indices were within specifications

Cement Plant Application

Successful field testing of C-PAC at a number of cement plants (data proprietary of Albemarle and the plants)



Cement Kiln with no Mercury Control



Cement Kiln with C-PAC™ Mercury Control

Conclusions

- **Successful Development of an innovative concrete friendly matric (ABI)**
- **Determined the range of ABI that results in concrete compatibility (no AEA adsorption)**
- **Design of a one-step activation process to achieve the desired ABI**
- **Successful production of C-PAC; high Hg removal in field trials and long-term commercial applications**
- **No adverse effect on the quality of concrete**

References

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