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

August 2, 2012

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

Behrooz Ghorishi (R&D Director); behrooz.ghorishi@albemarle.com
• 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
• **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
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 (a 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
• 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
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
Concrete with baseline fly ash  With C-PAC

All foam indices were within specifications
Successful field testing of C-PAC at a number of cement plants (data proprietary of Albemarle and the plants)
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


Qunhui Zhou, Sid Nelson Jr., et al., Concretes and Fly Ashes from a Full-Scale Concrete-Friendly™ C-PAC™ Mercury Control Trial, Proceedings of World of Coal Ash Conference, 2007