Civil and Environmental Engineering
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Characterization of the Physical, Thermal and Adsorption Properties of a Series of Activated Carbon Fiber Cloths

S-Y. Lo, D. Ramirez, C.M.B. Lehmann and M.J. Rood
Department of Civil and Environmental Engineering
University of Illinois at Urbana-Champaign

K. James Hay
Construction Engineering Research Laboratory
U.S. Army Corps of Engineers, Champaign, IL

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  - Physical Adsorption
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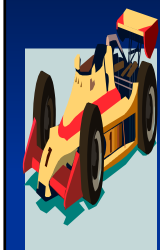
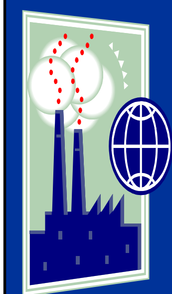
  - Cost of ACFCs vs GACs
- Materials And Methods
  - What ACFCs Are Characterized ?
  - What Properties ?
- Results
  - Physical, Thermal and Adsorption Properties
- Conclusions

Volatile Organic Compounds



- Human and industrial activities release large amounts of volatile organic compounds (VOCs)
- In 1999, 9×10^{8} kg of toxic chemicals were emitted into the atmosphere (USEPA, 2001)
  * 29% was due to solvent utilization



- Maximum Achievable Control Technology (MACT) standards are used to decrease hazardous air pollutants emissions

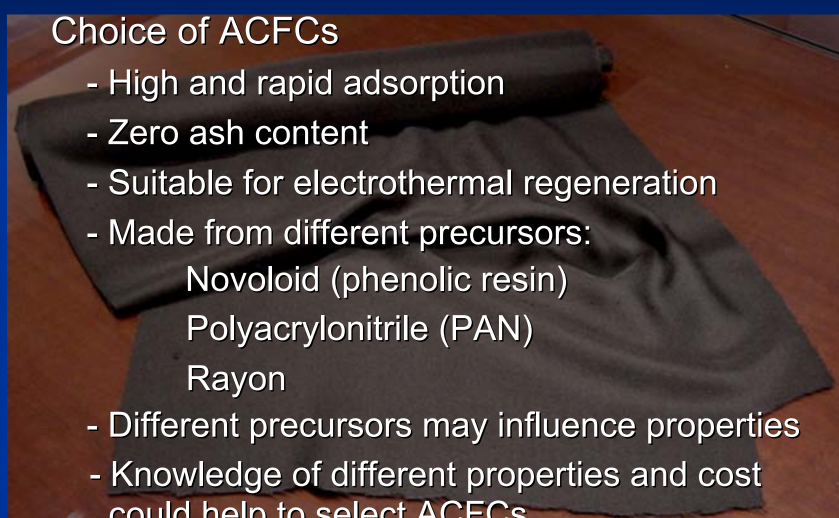
Physical Adsorption

- Physical adsorption is commonly used for emission control of gaseous pollutants
- Selectively removes VOCs from gas streams due to intermolecular forces between the adsorbate and adsorbent
- Reversible process using temperature or pressure swing desorption
- Activated carbon is a commonly used adsorbent
- Different forms: granules (GACs) or cloths (ACFCs)

Objective

Characterize the physical, thermal and adsorption properties of a series of commercial ACFCs in order to select the most appropriate adsorbent for the design of industrial systems to capture and recover hazardous and volatile organic compounds from gas streams

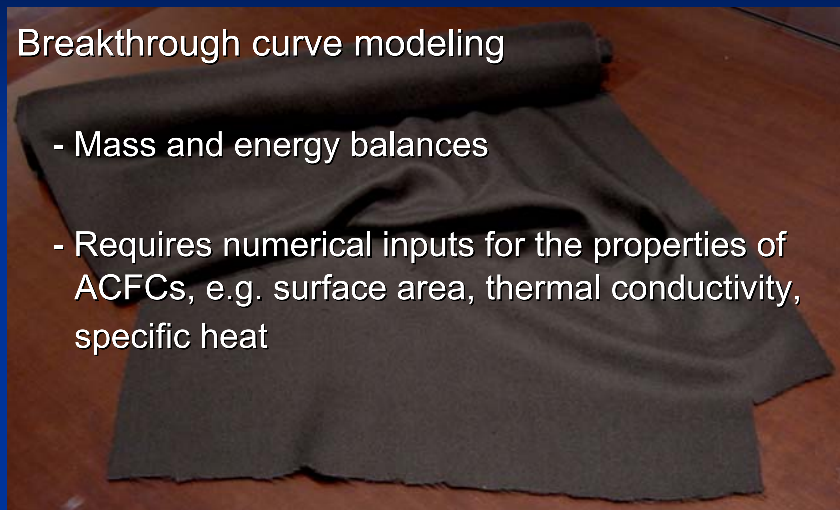
Why Characterize ACFCs?



Choice of ACFCs

- High and rapid adsorption
- Zero ash content
- Suitable for electrothermal regeneration
- Made from different precursors:
    - Novoloid (phenolic resin)
    - Polyacrylonitrile (PAN)
    - Rayon
- Different precursors may influence properties
- Knowledge of different properties and cost could help to select ACFCs

Why Characterize ACFCs?



Breakthrough curve modeling

- Mass and energy balances

- Requires numerical inputs for the properties of ACFCs, e.g. surface area, thermal conductivity, specific heat

Cost of ACFCs vs GACs

ACFC	GAC
Novoloid-based ($240/kg to $1028/kg)	$1.60/kg to $2.70/kg (USEPA, 2000)
PAN-based ($200/kg to $1372/kg)	
Rayon-based ($200/kg to $372/kg)	

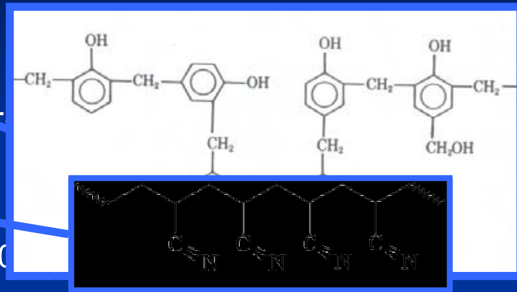
What ACFCs are Characterized?

* Novoloid-based ACFCs:

ACC series
(ACC-5092-10, -15, -20, -

* PAN-based ACFCs:

AW series
(AW1101, 1102, 1501, 20



* Rayon-based ACFCs:

FM series
(FM-1/250, -5/250, -5K/250)

WWP3, WKL20, RS1301

RC series (RC-60, -200)

$(C_6H_{10}O_5)_n$

What Properties are Characterized?

Physical properties

- Surface area
- Pore volume
- Pore size distribution
- Morphology
- Density
- Electrical resistivity

ACFC

Thermal properties

- Thermal conductivity
- Specific heat
- Thermal stability

Adsorption properties

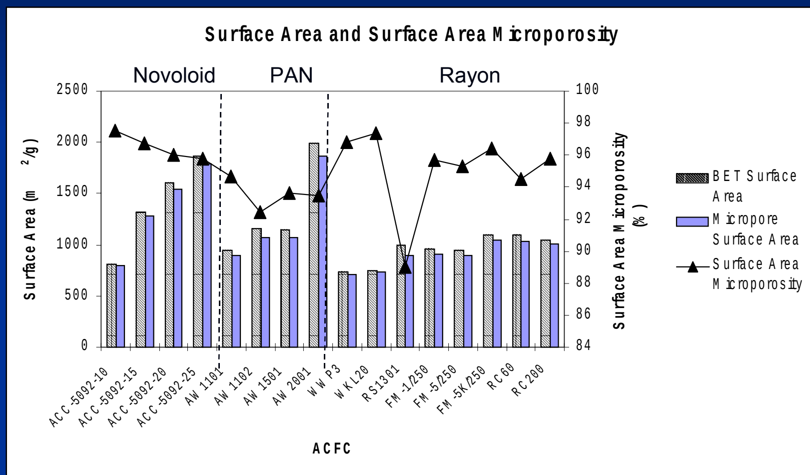
- MEK adsorption capacity

Physical Properties

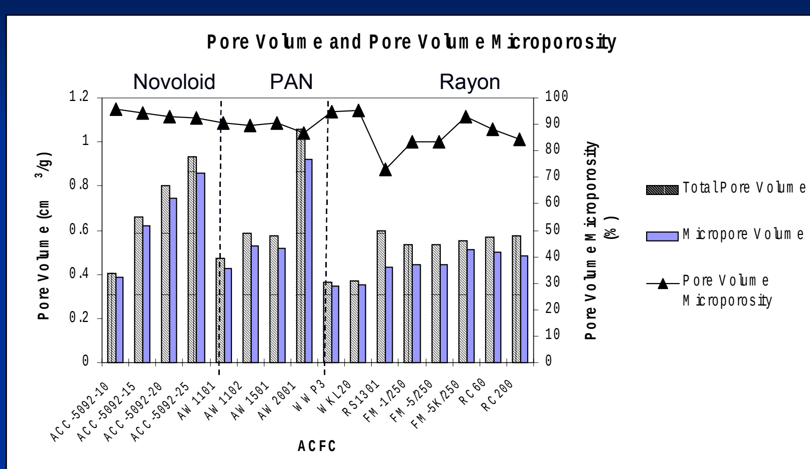
Physical Characterization

Method	Property
N_2 adsorption isotherm	Surface area Pore volume Pore size distribution
Scanning electron microscopy (SEM)	Morphology
Pycnometry	Density
Electrical resistance	Electrical resistivity

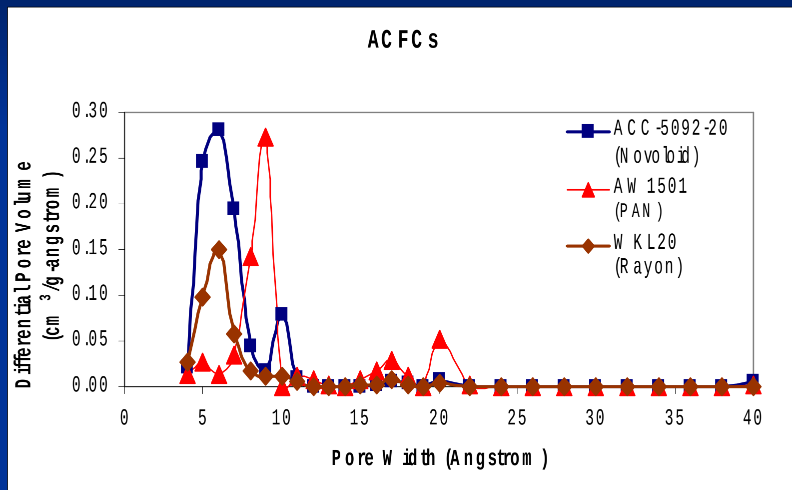
Surface Area and Pore Volume



Surface Area and Pore Volume

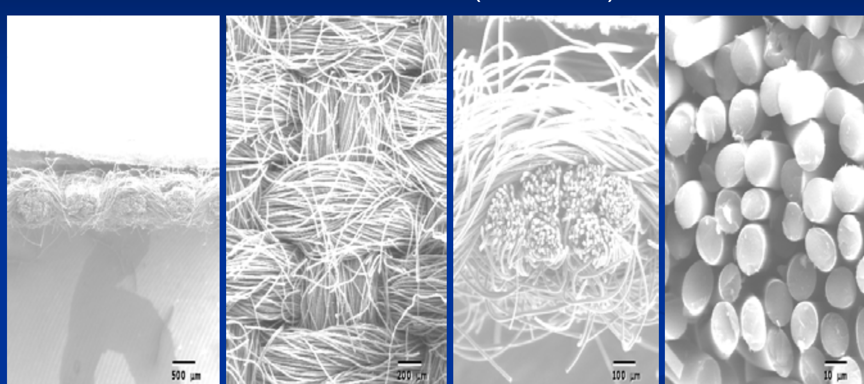


Pore Size Distribution



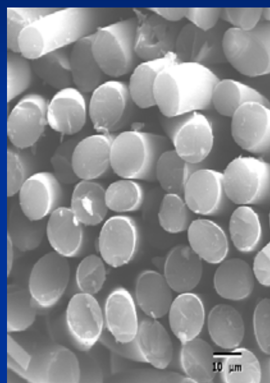
Morphology

ACC-5092-25 (Novoloid)

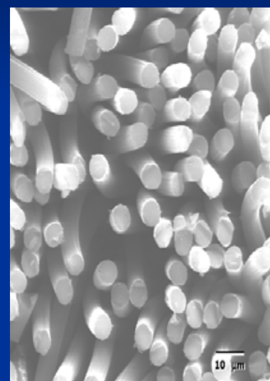


20 × 50 × 100 × 1000 ×

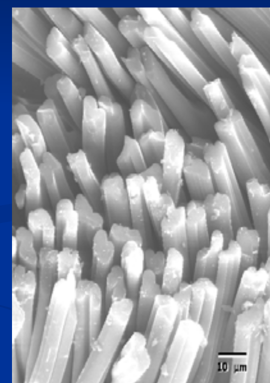
Morphology



ACC-5092-25
(Novoloid)

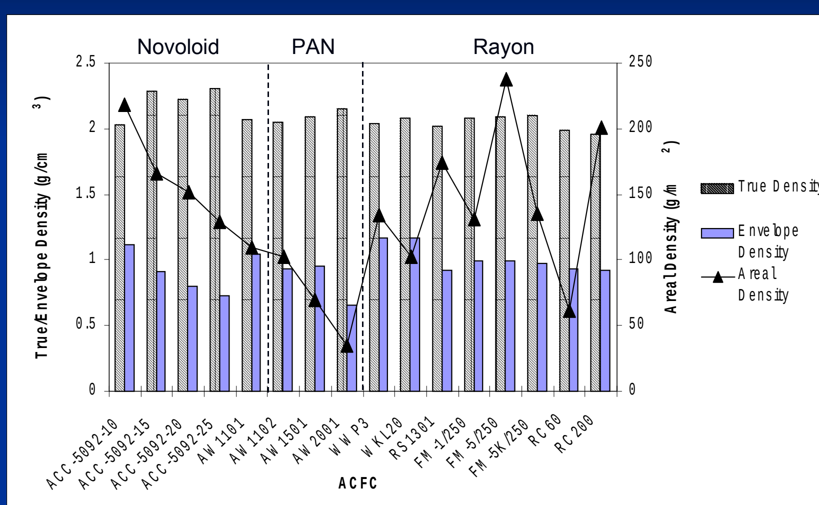


AW1102
(PAN)

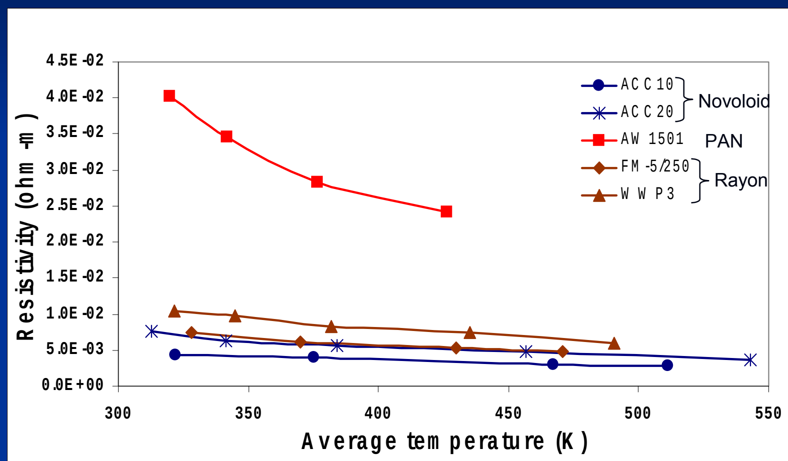


WKL20
(Rayon)

Density



Electrical Resistivity

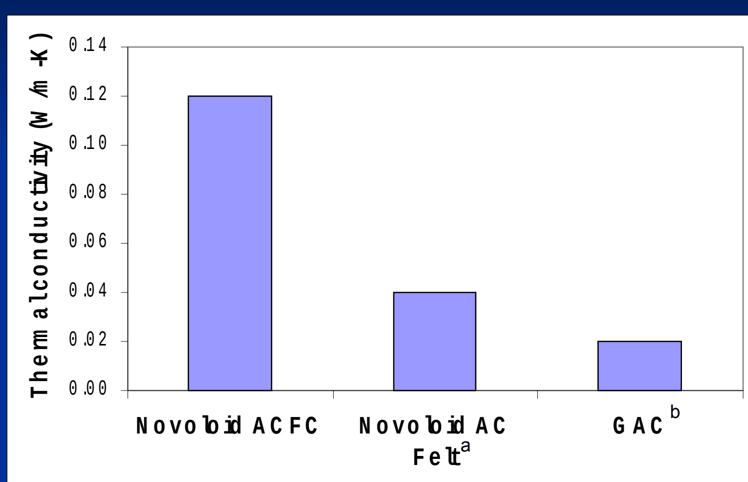


Thermal Properties

Thermal Characterization

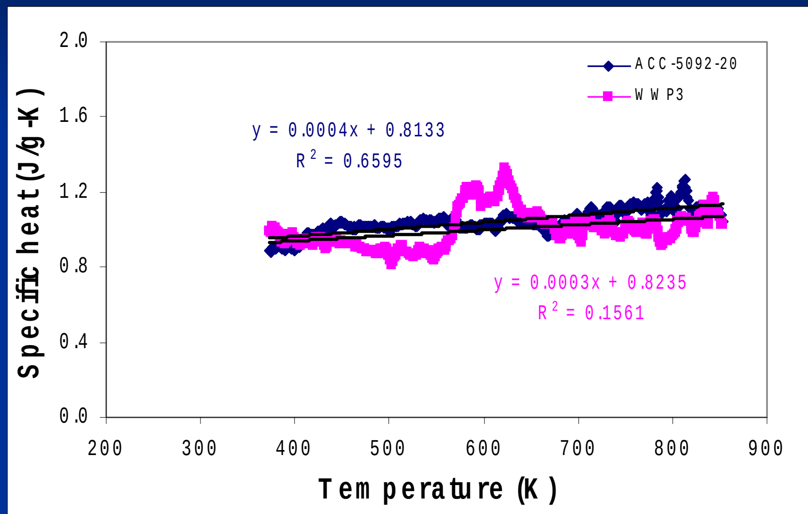
Method	Property
Hot plate method	Thermal conductivity
Differential scanning calorimetry (DSC)	Specific heat
Thermogravimetry analysis (TGA)	Thermal stability

Thermal Conductivity

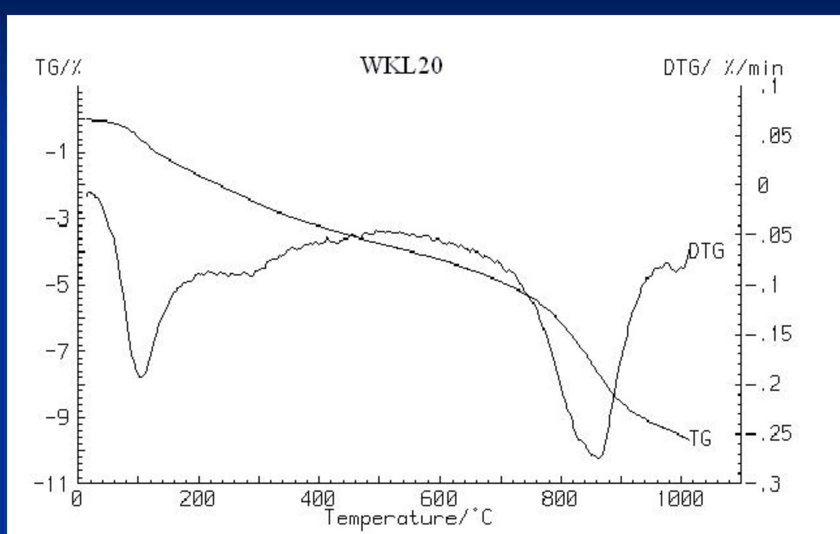


[a] American Kynol, 2001 [b] Calgon Carbon, 2002

Specific Heat



Thermal Stability



Adsorption Properties

Adsorption Characterization

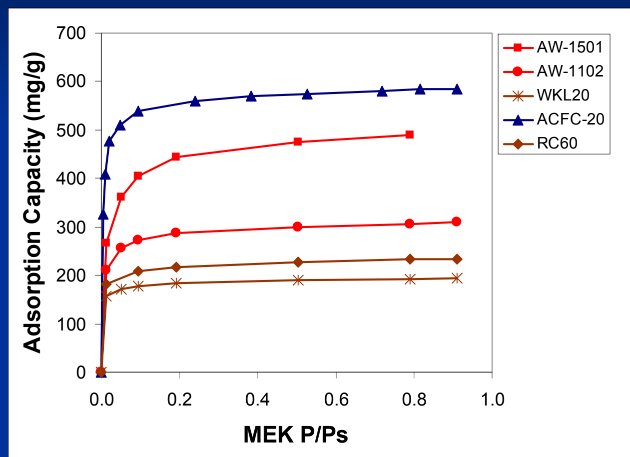
Method

Gravimetric measurement →

Property

Adsorption capacity

MEK Adsorption Isotherms



Conclusions

- Large surface area and pore volume → large adsorption capacity
- Narrow micropore size distribution → enhanced adsorption
- True densities similar irrespective of precursors
- Novoloid ACFCs are recommended because of:
  a) lowest electrical resistivity
  b) better heat transfer characteristics suitable for electrothermal regeneration
  c) highest thermal stability

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