RARE EARTH AND CRITICAL MATERIALS
DECEMBER 6, 2010 IN ARLINGTON, VA

Breakout Sessions:

Catalysts and Separators

CATALYSTS AND SEPARATORS: BACKGROUND

- Rare earth oxides, such as Ceria, are used significantly in applications involving oxygen catalysis and transport through ceramic separators.
- Application examples include: fluid catalytic cracking, post-combustion catalytic conversion, high temperature diffusion electrolyte separators
- This workshop will explore over-the-horizon, new technical solutions, providing alternatives or completely new pathways, for the replacement of rare-earth materials in catalysis and separator applications.

CATALYSTS AND SEPARATORS: QUESTIONS

- Are there alternatives, e.g. mesoporous zeolites, to the high use of rare-earths in fluid catalytic cracking?
  - What are the limits in controlling size and shape to dramatically increase performance?
  - What are the ultimate limits and by what quantitative amount could the process be improved while reducing rare-earth content?
- In high diffusivity oxygen separators, are there potential technologies not containing critical materials with the combination of oxygen permeability and mechanical integrity at high temperatures?
- Can the unique structures of graphene or nanotubes be developed into new catalyst technologies?

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CATALYSTS AND SEPARATORS: METRICS

FCC Catalysts:

(Exceed current SoA with reduced rare-earth content)

Loading: <.045 kg / bbl

Microactivity Test (MAT) > 80% conversion

Less than 1% Rare Earth Content

Compatible with for existing refining infrastructure

SOFC Separators and Catalysts:

(SECA Targets, w/reduced RE content)

Low or no Lanthanum content cathode (<5% by mass)

Low RE oxygen permeable ceramics (<2% yttria)

>0.5 A/cm2 at 750C at 40mV over-potential

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CATALYSTS QUESTIONS

- Are there alternatives, e.g. mesoporous zeolites, to the high use of rare-earths in fluid catalytic cracking?
  - Zeolites are not the limiting part of the problem – REs added to zeolites in varying quantities from 0-8%; of catalysts that use REs, 3% is typical
  - Recycling/recovery by FCC industry?
  - What are the limits in controlling size and shape to dramatically increase performance? Smaller particles result in thermal instability – RE content is secondary questions, theoretically would give enhanced selectivity
  - What are the ultimate limits and by what quantitative amount could the process be improved while reducing rare-earth content?
  - Processes (not just materials) – longer timeline due high costs of process changes
  - Biocatalysts with high thermal stability

SEPARATORS QUESTIONS

- In high diffusivity oxygen separators, are there potential technologies not containing critical materials with the combination of oxygen permeability and mechanical integrity at high temperatures?
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Costs of catalysts are small part of refining, these metrics can be implemented but with increased used of FCC rather than REs

SOFC Separators and Catalysts:

(SECA Targets, w/reduced RE content)

Low or no Lanthanum content cathode (<5% by mass)

Changes in cathodes very difficult, currently 25% by mass

Low RE oxygen permeable ceramics (<2% yttria)

>0.5 A/cm2 at 750C at 40mV over-potential

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FCCS

- REEs added for stability of FCCs
- Content of specific REEs varies based on current market prices; can be unrefined mixtures, pure La, etc.
- Economics of recovery has not been right for FCC manufacturers; might be at current prices
- Transition metal could possibly be used as stabilizers – not as active and is a step backward for Y zeolites
- Transition metals may be a exploration area to stabilize mesoporous zeolites
- Cost of REs not a big cost concern – supply is the concern
- White spaces : recycling of FCC catalysts to extract Lanthanum/REs (partnering of FCC manufacturing with metallurgy extractors)

THREE WAY AUTOMOTIVE CATALYSTS

- Ceria is primary rare earth used but in conjunction with other REs
- Is there an ARPA-E play here? (we suspect no)
- Tradeoffs between RE metals and platinum group metals – REs make PGMs more efficient in addition to other purposes

SOLID OXIDE FUEL CELLS

- SOFC stack is only 25-35% of the cost of system, most of that cost is processing not materials, replacing REs would not reduce costs much
- Lower dopant content possible in anode support where ionic conductivity is not essential – Sc, Mg, Ca are possibilities where conductivity is not needed as much
- Westinghouse has shown that can use La, Nd, Pr, Ce, Sm mixture in place of pure La in (La,Sr)MnO
- Areas of research: new electrocatalysts that facilitate rxns and multi-phase boundary, new mixed-ion conductors, alternative stabilizers and dopants with comparable ionic and electronic conductivity, advanced scalable synthesis methods for new materials, fabrication technology for low dimension structures, manufacturing process development

GRAPHENE/CNT

- Graphene used in alcohol oxidations, alkene oxidations, alkyne hydrations, C-C bond forming reactions
- High yields and fast reaction rates
- Would this be applicable to FCCs?
- Completely different process; when could it realistically be adopted (decades away)