







An Overview of CENT: Developing nanomaterials for petroleum & petrochemicals applications





Zain Yamani CENT Director 16-10-1432 14-9-2011





Outline:





- 1- What is CENT?
- 2- A bit of History
- 3- CENT Structure, Objectives

and personnel

- 4- What is CENT working on?
- 5- CENT Labs
- 6- Welcome to CENT





What is CENT?

Center of Excellence in Nanotechnology



A KFUPM organ founded in November 2007, based on Royal Fund donation in Nov. 2006



A KFUPM research center committed to developing nanomaterials for applications in petroleum and petrochemicals



CENT History in a Nut-Shell

- 2006: NNC WS, King Donation

- 2007: CENT interim, CENT Kick-off Workshop, Founding appointment.

- 2008: CENT development (Executives Committee, Five-Year Plan, BoD Meeting, ABM Meeting, projects approvals, start staffing with post-docs.

- 2009: affiliates running projects, establishing ties with Industry & Int'l Collaborators, Education (NTGP, SMP, CNT WS, Seminars), procuring & recruiting, focus areas "established".

- 2010/11: full time researchers and engineers, labs development, major equipment, technical (thrust) groups



CENT Structure





CENT: Objectives

1. To build up world-class human resources research capacity including highly qualified research scientists, staff and trained graduate students in the field of nanomaterials synthesis, their characterization and relevant applications.

2. To develop research infrastructure including state of the art facilities that enables the Center to achieve its goals.

3. To create innovative nanotechnology-based solutions in strategic areas in petroleum and petrochemical industries relevant to the Kingdom.

4. To establish Industrial Partnerships with relevant companies and entrepreneurships as a step toward commercialization, in coordination with DTV.

5. To contribute to the development of teaching graduate programs and training students in the field of nanotechnology.

6. To promote public awareness regarding the benefits and the risks of nanotechnology.



CENT Personnel











RA:1, 2, 3, 4, 5



SMP:

1

2 3

4

5

























CENT Affiliates:

Abdullah Al-Sultan Abdullah Al-Sunaidi Abdul-Nasir Kawde Amjad Khalil Anwar-ul-Hamid Bassam Tawabini **Basheer** Chabanashi Khalid Al-Hooshani Mazen Khaled Mamdouh Al-Harthi M. Ashraf Gondal Moataz Ali Atieh Mohamed Faiz Nabeel Maalej Nahidh Siddique Nasser Ageeli Nouri Hasan NisarulLah Nouar Tabet Saheb Nouari Saleh Al-Ouraishi Syed Ahmed Ali Tahar Laoui

PETE **Physics** Chemistry Physics CER ES Chemistry Chemistry Chemistry Chem. Eng. Physics Chem. Eng. Physics **Physics** Chemistry Mech. Eng. Chemistry Chemistry Physics Mech. Eng. **Physics** CRP Mech. Eng.

sultanas@kfupm.edu.sa asunaidi@kfupm.edu.sa akawde@kfupm.edu.sa amjadb@kfupm.edu.sa anwar@kfupm.edu.sa bassamst@kfupm.edu.sa cbasheer@kfupm.edu.sa hooshani@kfupm.edu.sa mkhaled@kfupm.edu.sa mamdouh@kfupm.edu.sa magondal@kfupm.edu.sa motazali@kfupm.edu.sa mmfaiz@kfupm.edu.sa maalej@kfupm.edu.sa mnahid@kfupm.edu.sa nageeli@kfupm.edu.sa nhassan@kfupm.edu.sa nullah@kfupm.edu.sa natabet@kfupm.edu.sa nouari@kfupm.edu.sa salehq@kfupm.edu.sa ahmedali@kfupm.edu.sa tlaoui@kfupm.edu.sa



What is CENT Working on?

Focus on the petroleum and petrochemical industries

- 1. Nano-engineered Catalytic and Photocatalytic Materials
- 2. Nano-structured Materials for Sensing Applications







EXAMPLES OF RESEARCH AT CENT



NCMs Research Areas

NCMs group has identified three research areas as :

- 1. Fuel Energy: Development of high surface area and shape tailored NCMs for oil and gas related applications. This includes, removal of sulfur, nitrogen, heavy metal, etc.
- 2. Photo Energy: Development of photo-active nanostructured materials. These materials will be used for water decontamination, carbon dioxide conversion, and hydrogen generation.

3. Electrochemical Energy: Design and development of NCMs for energy conversion applications. Our aim is to come up with ultra-low noble metals and/or noble metal-free catalysts supported on high surface area and conductive composites.



MP as 100% DS catalyst

Kaile Wang et al., Energy Fuels 2009,





Project Title: Study of the Structural Properties and Hydrodesulfurization Activity of MoS₂ and Co/Ni/MoS₂ Catalysts Prepared by Laser Pyrolysis

| Investigators: | PI: Zain Yamani ⁽¹⁾ Co-I: N. Tabet ⁽¹⁾ , Co-I: S. Ali ⁽²⁾ Frederick Schuster ⁽³⁾ Hicham MASKROT ⁽³⁾ (1) Center of Excellence in Nanotechnology and Physics Department, KFUPM (2) Center for Refining and Petrochemicals KEUPM |
|----------------|---|
| | (2) Center for Refining and Petrochemicals, KFUPM(3) Advanced materials Program, CEA-France |

A 3-way collaboration, a subject that is important to the Kingdom, potentially supported by the Industry, potential IP ownership, not that much overhead



Adv. Mater. 2006, 18, 2561–2564

Figure 1. SEM images of a) 2H-MoS₂ powder, b) 2H-MoS₂ powder with 5.8 wt% Ni, c) MoS₂ nanotubes, d) MoS₂ nanotubes with 5.3 wt% Ni, e) MoS₂ nanotubes with 25.5 wt% Ni, f) MoS₂ nanotubes with 5.5 wt% Ni, f) MoS₂ nanotubes wt% Ni, f) MoS₂ nanotu

By Fangyi Cheng, Jun Chen,* and Xinglong Gou

Fabrication of NP Impregnation Characterization Testing for HDS



Schuster, CEA-France

We like to build a larger team in the field of nano-engineered catalysis



Zeolite Nanocrystals @ CENT



Framework: MFI Crystal size: 80 nm Crystal shape: Nanospheres Pore system: 3D Pore size: 0.51 x 0.55, 0.53 x 0.56 nm

> **Target Applications:** Catalytic cracking Alkylation Hydroisomerization etc

Framework: TON Crystal length: 300-400 nm Crystal shape: Nanorods Pore system: 1D Pore size: 0.46 x 0.57 nm

Muraza et al. (in preparation)



Pulsed Laser Ablation for synthesis of nanostructures and development of nano-photocatalysts



M.A. Gondal









NCS: Nano-structured Chemical Sensors



Zinc Oxide Nanowires/ Nanodots

N. Tabet et. al (Physics & CENT)

Dynamic and fast response of MW ZnO nanowires to H_2 gas at different temperatures









S. Aramco project

It used to be robots in blood arteries?!!











DHAHRAN, November 19, 2008 -- The EXPEC Advanced Research Center (EXPEC ARC) won the prestigious New Horizons Idea Award at the 2008 World Oil Awards. The award was granted for the research and innovation of Resbots (reservoir robots).

Excellence in NanoTechn

Resbots are nanorobots, less than 1/100th the size of the human hair, that can move through the reservoir. They will be deployed as a microscopic army with injected water into the reservoir. During their journey, they will analyze reservoir pressure, temperature and fluid type, and store that information in onboard memory. They will then be picked up from the produced crude at the producing wells to download that information and tell us everything about the reservoir they have encountered during their journey, thus effectively mapping the reservoir.











NT in Petroleum-EOR





2 years later: Novel Hybrid Reservoir Nano-Agents for Enhanced Oil Recovery Proposal submitted by Z. Yamani et. al. for S. Aramco EXPEC ARC funding!!







Goal: smart tracing, sensing, and sniffing devices for on-line implementation in oil fields





NT in Petroleum-EOR







Improve on current single well chemical tracers (SWCT)

Measure residual oil saturation

Map the oil reservoir







There are a LOT of difficulties and uncertainties; yet, IF this technology improves EOR by even a single percent, that is a LOT of Oil!!



Formula 1 for Nanotechno

NT in Petroleum-EOR

Challenging problem:

- "Right" size,
- Dispersibility,
- Functionalization,
- Harsh environment,
- Choice of markers/ sensitive detection (chemical, optical, electrical, magnetic)













NT in Petroleum-EOR







Then what ..??

Bring resbot to life?? (active vs. passive)

Propulsion; Navigation; Communication; Ammunition;





(for now!!)

The resbots are not 'really' robots.. but rather (just) 'agents'





Nano Agents

- Nano Silica Particles
- Nano Polymer Particles
- Nano paramagnetic Particles

Functionalities

- Optical
- Fluorescent
- Magnetic
- Chemically Reactive Material



COLOR CODED SENSING AGENTS

Silica Encapsulation of Sensing Agents



Silica shell having colored aqueous core

Fluorescent Nano Particles



PMMA Particles coded with DiOC18 Dye

Sufyan Khan



TREATING CHEMICALS AND MAGNETIC AGENTS FOR RESERVOIR

Nano Particles For Reservoir Chemical Treating Materials





Particles For Paramagnetic Sensing



Encapsulation of nagnetite Particle

Sufyan Khan





Nano-Carbon Research Unit

Fabrication and Design of Reactors

Synthesis and Characterization

Applications

















NCRU applications

- Improving of the mechanical properties of composite polymers
- Catalyst for polymerization (or inhibition)
- Developing rubber super tires
- Improving heat exchanging
- Water decontamination















Current and Proposed CENT projects



Current [NSTIP] projects (2010-2012) overseen by CENT

| # | Title | Focus Area | PI |
|---|---|---------------|---------------------------|
| 1 | Development of Metal-Oxide Zeolite Nanostructures for Hydrogen and Hydrogen Sulfide Detection | Catalysis | Zain Yamani |
| 2 | Treatment of water contaminated with MTBE by Photo- TiO2 system and carbon nanotubes (CNTs) | CNT | Bassam Tawabini |
| 3 | Effect Of Radiation Vulcanization And Conventional Vulcanization On The Mechanical And Physical Properties Natural Rubber / Carbon Nanotubes Nanocomposite | CNT | Mo'taz Atieh |
| 4 | Biocompatible and Biodegradable Polymer Nanoparticles for Cancer Cell Imaging. | sensors | N. Maalej |
| 5 | Development of Point-of-Care Biosensors for Breast Cancer Diagnosis | sensors | Abdul- Nasser Kawde |

29



Other CENT projects (2011-2013)

| # | Title | Focus Area | PI |
|---|--|----------------------|---------------------------|
| 1 | Development of Carbon Nanotube-Based Electrochemical Sensors for Monitoring of Toxic Phenolic Contaminants in Petroleum Industrial Wastewater. [CENT funded (NCS), started April-2011] | CNT/sensor | Abdel- Nasser Kawde |
| 2 | Novel Hybrid Reservoir Nano-Agents for Enhanced Oil Recovery (contract drafted with S. Aramco) | Sensing | Zain Yamani |
| 3 | 3 projects for the KFUPM-S. Aramco –KAIST 3-way collaboration (big possibility for endorsement) | Carbon Management | Basheer, Gondal |



CENT NSTIP funded Projects

[3rd Cycle start September, 2011]

Development of advanced and functional nano-structured mesoporous zeolites for hydrodesulphurization and other catalytic applications in petroleum and petrochemicals (Qamar)

Development of highly efficient visible-light-driven nanostructured materials for photocatalytic applications (Qamar)

Carbon Nanofibers Grown on 3-D Solid Structures for Applications in Energy-Related Catalysis (Oki)

Zeolite Nanosheets as a Materials Platform for Improved Refining Catalysts (Oki)

Development of Nitrogen-Modified CNTs as Pt-Free Catalysts for Fuel Cells (Belabbes)

Design of Smart Fluids for Acid Delivery in Well Stimulation Treatment (A. Sultan)

Lanthanide-doped oxide nanoparticles for Multi-modality Molecular Imaging Agents (Maalej)



NSTIP 5th Cycle Projects [proposed May 2011]

Electrochemical Tailoring of Nano-structured Metal Phosphides for Clean Energy (Belabbes)

Engineered Porous Catalytic Nano-Architectures for Conversion of Natural Gas Derivatives to Fuels and Chemicals (Oki)

Development of nanostructured visible-light-driven silver-based oxides for water decontamination (S. Khan)

Investigation of Micro and Nanogap electrode based Nanostructures Sensors for ultrafast detection of Hydrogen (Ahsan)

Development of hybrid system based on photo- and electro-active nanostructured materials and redox mediators for reduction of CO_2 (Qamar)

Synthesis of N- and F-doped TiO2 photo-catalyst for Hydrogen Production under Visible Light Irradiation (Gondal)



Publications



Ultra fast synthesis of zinc oxide nanostructures by microwaves

N. Tabet 4*, R. Al Ghashani^a, S. Achour^b ¹ Mysels Department, Center of Excellence in Neutotechnology (CENT), King Fahl Univ ⁶ Commits Laboratory, University Mestauri, 25056 Constantine, Algoria

| ARTICLE INFO | ABSTRACT |
|--------------------------------|------------------------|
| Article kinney: | We describe a novel n |
| Bacelved 28 November 2008 | oxide powder using a |
| Bacelved in revised from | composite showing a |
| 19 February 2029 | used as a microwowe 1 |
| Accepted 3 March 2009 | exceeding 1700 °C or |
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nding address: Physics Department, Center of East-Serve in Nanotechnology (CENT) d Naterals, PO Ros 477, 31281 Distance, Saudi Arabia, Tell: +966 38600445; Doc: +866 Dress: natabat@Mispiterida.cs.(N. Taber).

1. Introductio



© 2000 Elsevier



Moving Enzyme-Linked ImmunoSorbent Assay to the Point-of-Care Dry-Reagent Strip Bis

Bacoinud: 10 May 2009; | Revised: 13 July 2009; | Accepted: 27 Ja

Abstract In this work, we described a point-of-care (POC) day-re-tacers and portable strip reader for simple, low-cost and a liferentialith Pennsidae. (HPR) and Rubbet IgG (FelGe) were of the proto-for-concern. The analysic-lay minimumeticity tracers were captured on the task zone of the biosener. To come the preserve of the immediate information of the pre-tage of the preserve of the concern for toph the immediate information of the preserve of the other of the pre-tage of the pre-serve of the task of the pre-tage of the pre-serve of the other of the term concern distributed and the pre-serve of the task of the term concern distributed and the pre-serve of the pre-tage of the pre-tage of the pre-tage of the pre-tage of the pre-serve of the pre-tage of

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Keywords: ELISA; Biosensor; Enzyme; Point-of-care; Dry-r

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Synthesis of highly active nanocrystalline WO3 and its application in laser-induced photocatalytic removal of a dye from v



Cardyon Communications 18 (2009) 1988-1984

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Reagent Strip Biosensors

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American Journal of Biomedical Science: ISSN: 1937-9980 nwpii.com/ajbm

UNITED STATES PATENT AND TRADEMARK OFFICE CERTIFICATE OF CORRECTION

PATENT NO. : 6,846,474 B2 DATED : January 25, 2005 INVENTOR(S) : Nayfish et al. Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page. Iom [50, Breferences Ched, OTHER PUBLICATIONS, "M.H. Nuyfeh, Z. Yarnani et al. "reference, between "Porous" and "Using" insert – Silicon –; "W.H. Toongron al. "reference, deliter "L.H. Abu Hassan" and insert – L.H. Abu Hassan – therefer; and "W.H. Toongron al." reference, deliter "M.A. Hassan" and insert – M.A. Hassan – "W.H. Toongron al." reference, deliter "M.A. Hassan" and insert – M.A. Hassan –

Column 8. Line 30, delete "Presebt* and insert -- Present -- therefor

 $\underline{Column~9_s}$ Line 24, between "viscosity" and "=10"" delete "x" and insert -- η -- therefor Line 24, delete "Boltzman" and insert -- Boltzmann -- therefor

 $\underline{Column~11}_{\star}$ Line 28, between "uniform size of" and "1 nm in diameter" insert — — —

Column 15. Line 8, delete "2 m" and insert -- 2 µm -- therefor



Signed and Sealed this Ninth Day of August, 2005



JON W. DUDAS Director of the United States Patent and Tradewark Office



| (12) United States Patent - Al-Quraishi | | | (10) Patent No.: US 7,601,324 B1 (45) Date of Patent: Oct. 13, 2009 | | | |
|--|--|---|---|--|---|--|
| (54) | 54) METHOD FOR SYNTHESIZING METAL OXIDE | | 0.416.062 31* 72082 Kngsi et al | | | |
| (75) | Investors | Seleh I. Al-Quraishi, Distance (SA) | 6,83 | 019 01 12:2004 | Lewis, III et al. | |
| (73) | Assignee | King Fahd University of Petroleum and Mitterals, Dhahran (SA) | 7,05 7,05 7,06 7,06 7,01 | A16 31 * \$2005 A66 31 * \$2005 A66 32 * \$2005 236 32 \$2007 | Karthura et al. Kimball et al | |
| (*) | Notice | Subject to my disclaimer, the term of this potenti is submided or adjusted under 35 | 2013 010 | 332 BL 92008 683 A1* 62003 | Reitz et al | |
| | | U.S.C. 154(b) by 0 days. | | (Con | tinuel) | |
| (21) | Appl. No. | 12/216,835 | | FOREIGN PATER | NT DOCUMENTS | |
| (22) | Filed | Ard. 11. 2008 | CA | 2456765 A1 | 5/2003 | |
| | | | | (Cort | tioned) | |
| (24) | Int. Ch. 8248 5746 (2006.01) COJF 742 (2006.01) U.S. CL | | | OTHER PUT | REICALIONS | |
| (52) | | | Strackes (Vird annual meeting and expension of the American Commun Society).* | | | |
| | 425 | 423/21-423/186.04-25745-75042 | | (Cort | tiqued) | |
| (58) | Field of Classification Search | | | Primary Examiner - Metrin C Mayes Azalmant Examiner—Jan Li (74) America, Agent, or Piess—Richard C, Litzan | | |
| 100 | | Beforences Cited | (57) | ABST | RACT | |
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CENT Labs





Equipment on Campus

(For Synthesis & Characterization)



Focused Ion Beam Stations





Potentiostat/galvanostat



Contact Angle Measuring Device



TGA-DSC-MS



Autoclave

Ultra Performance LC









Pulsed Laser Deposition

The quartet in nanopowder metallurgy lab

Spark Plasma Sintering

Hot Isostatic Press

Cold Isostatic press

μ-wave sintering

Semiconductor device analyzer

Spectrofluorometer with combined steady state and lifetime capabilities

Automatic Sputter coater

Microwave reactor

Ultra Sonicator

Surface area analyzer

Particle size analyser

Gas Chromatograph

Planetary Ball Mill Machine

Furnace

CNT Application

Hot Press

Blender

1000 kg, 3 meters high Vertical Reactor in installation for large scale production of MWCNT

Towards Commercial Production of CNT

In situ Raman

Micro CT Scanner

Tensile testing machine for metals and polymers

Glove Box

Advanced Optical Microscope

Gas Chromatograph Mass Spectrometer

Systematic Steps to Get the Sample Analyzed

External Resources through Collaboration

Professor of solid state and material chemistry

Over 1400 publications

Prof. C.N.R. Rao

Prof. Rao has research laboratories at Jawaharlal Nehru Centre for advanced Scientific research as well as at the Indian Institute of Science, Bangalore

Some of his laboratory equipment available to CENT include

✤X-ray diffractometers

E-Beam lithographyFloating zone crystal growth apparatus

Closed cycle cryo-cooled 15 T superconducting magnet with optical window

Pulsed laser reactive ablation apparatus attached with mass spectrometer

Device LED, PV, FET measurement facilities

High Resolution Transmission Electron Microscope

Student Mentorship program

- Recruit (a limited number of) young and ambitious undergraduates
- ➤ Identify their interest and affiliate them to a research group
- Train them on several nanotechnology related techniques
- ➢ We familiarize them with essential laboratory instruments

The student is expected to have the ability to eventually run some equipment

He is also anticipated to participate in conducting research work

Finally, he gives a short talk on what he has learnt at the end of the semester

The idea is for CENT to catch them young, get them obsessed with research before Career Day!!

More at CENT..

Bi-weekly CENT Seminars

Visiting professors

Friends of CENT Mailing list

| Day | Date | Title of the Seminar | Speaker |
|---------|----------|---|---------------------------------|
| Day | Date | Title of the Seminar | Speaker |
| Sunday | 20/02/11 | Pushing Forward with the KFUPM Research Initiatives [CENT as an Example] | Dr. Zain H. Yamani |
| Tuesday | 1/03/11 | Magnetism of Nanowires | Dr. Del Atkinson |
| Tuesday | 08/03/11 | Introduction Nano-Catalysts for Natural Gas Conversion to Aromatics | Dr. Syed Hussain Tajammul |
| Tuesday | 22/03/11 | Hydrogen Fuel Cells as Green Energy Sources: Dream or Reality | Dr. Bel3abass |
| Tuesday | | Zeolite petroleum catalysis | Majnoni |
| Sunday | | With physics department | Dr. Ayman |
| Tuesday | | | Asep Bayu |
| Tuesday | | | Al-Somali |

NTGP: graduate program (under development)

Outreach efforts

www.kfupm.edu.sa/cent

web-site & forum

Welcome to CENT

KFUPM is committed to Developing Nanotechnology at KFUPM

Do not hesitate to contact us if you have suggestions or believe there is potential for collaboration/ affiliation.

Thank you for your attention