UNIVERSIDADE FEDERAL DE SANTA CATARINA

LABORATÓRIO INTERDISCIPLINAR DO DESENVOLVIMENTO DE NANOESTRUTURAS – LINDEN (SisNano/MCTI)

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NANOMATERIALS AND NANOCOMPOSITES FOR ENVIROMENTAL DECONTAMINATION

O LiNDEN TEM O i DA inovação

1st Brazil-China Seminar on Nanotechnology
March, 25 to 27, 2014

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NANOMATERIALS AND NANOCOMPOSITES FOR ENVIROMENTAL DECONTAMINATION

http://www.labmat.ufsc.br

http://www.lcp.enq.ufsc.br

http://www.polimat.ufsc.br

http://www.lacbio.ufsc.br

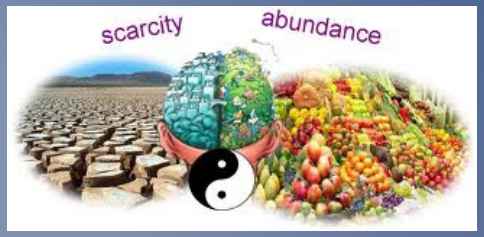
http://www.lcme.ufsc.br

OUTLINE OF THIS PRESENTANTION

- **Abundance and Scarticity OF WATER - "Brazil is a country of contrasts"**
- **Motivational, objectives and solution of nanotechnology**
- **Good exemples from nanotechnology**
- **FUNCTIONALIZED SURFACES (COATINGS):** *Use of polymer derived ceramics*
- **Polysilazane-derived antibacterial silver–ceramic nanocomposites**
- **Interfering in the Quorum sensing mechanism to avoid biofilm formation**

Abundance and Scarticity

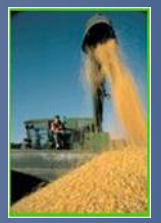
What we looking at here is **"Brazil is a country of contrasts"**



develop high tech solutions in fields as diverse as:

agriculture,



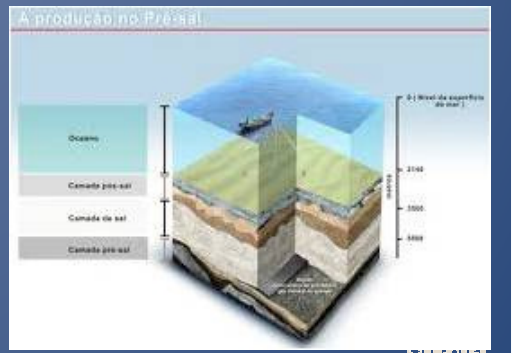



aviation

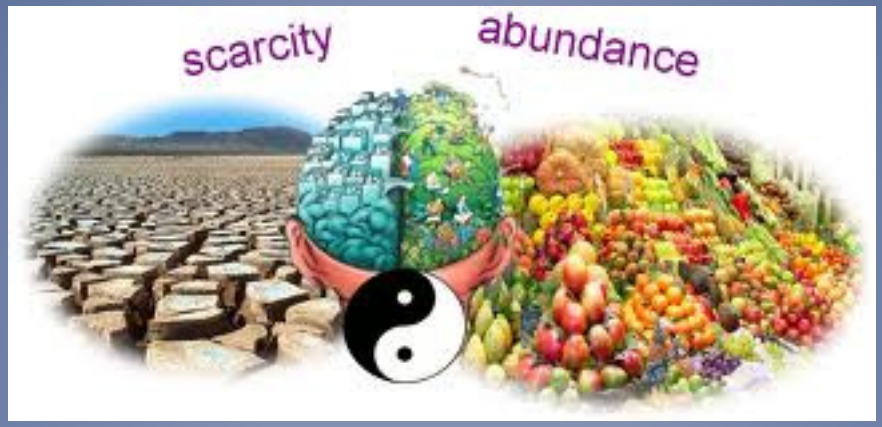


offshore deep water exploration





"Sriking contrasts"



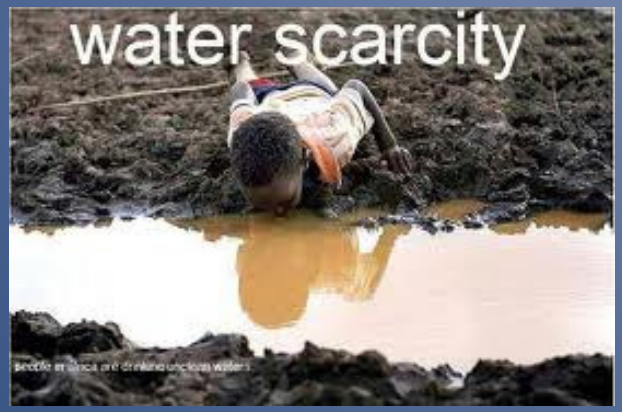
So, this was the situation : the nation still faces typical challenges of an under-developed country. **the major is the lack of means to bring clean water supply to the poorest regions of the country.**

WHAT MOVE US?
HOW TO MOVE FROM SCARCICITY TO ABUNDANCE AND PROVIDE OF PURE AND HEALTHY WATER TO SHORT INCOME POPULATION?

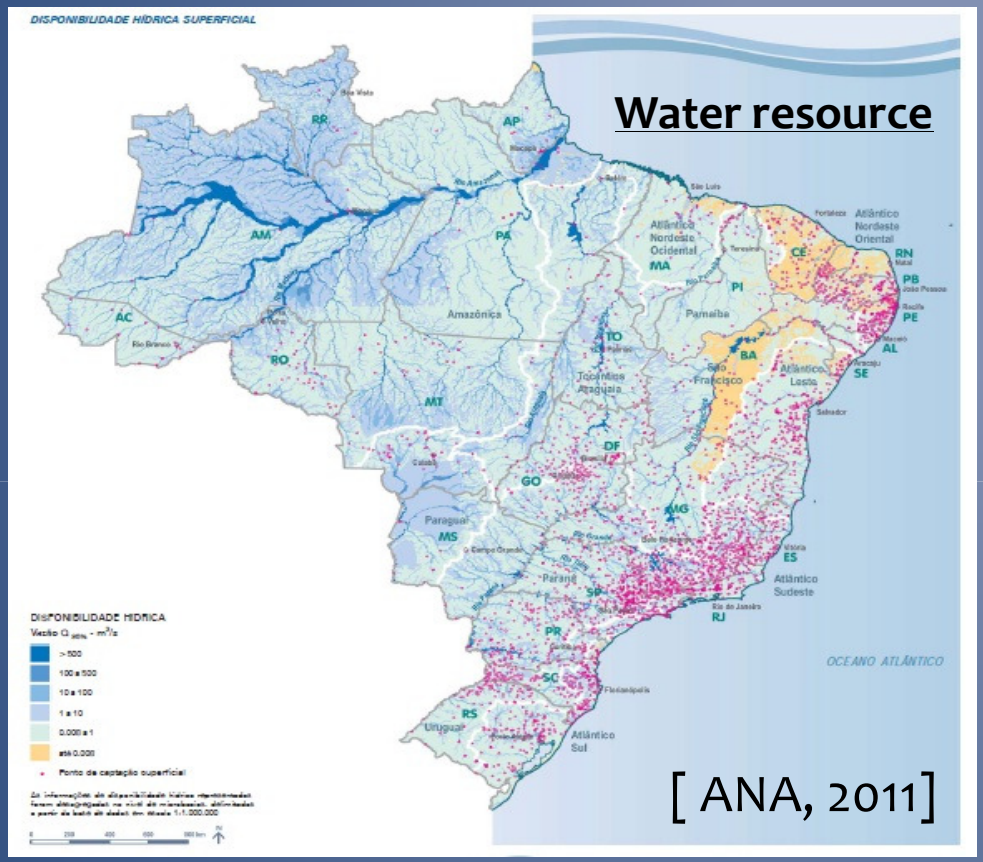
Motivational: we envised solutions of nanotechnology

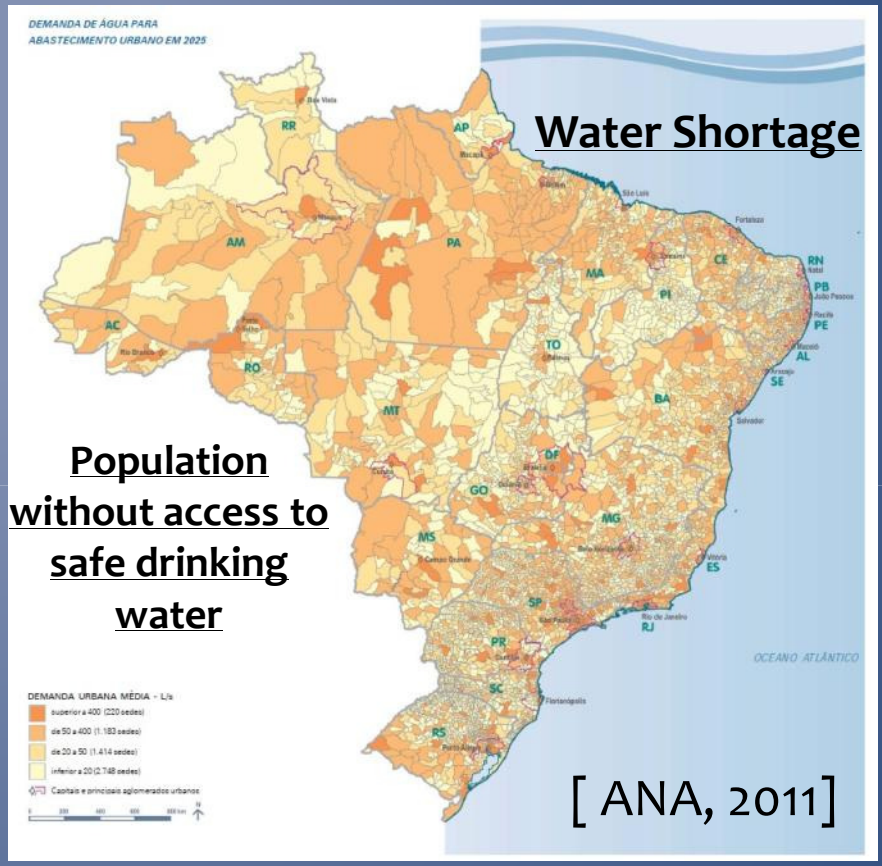
[ONU, 2011; ANA, 2011]

- *The dream of safe water for all is feaseble througth nanotechnology.*



SUPPLY OF WATER IN BRASIL





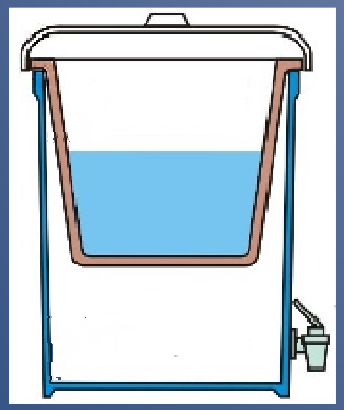
Natural resource essential to life
<0.02% of available water is drinkable
Brazil has largest reserve of fresh water

1 billion (14%) in the world
17 million (9%) in Brazil
82% in rural areas in Brazil

BY WHAT MEANS? LET'S JUMPING TO GOOD EXEMPLES FROM NANOTECHNOLOGY JUST TO CITE FEW

[PFP, 2011]

- *Potters for Peace (EUA, América Latina)*
  - *Ceramic Filters (0,6-3 µm) with coloidla Ag*
  - *Water flow: 1 to 2 l/h; volume: 5 a 20 l; lifetime: ~1 year*
  - *Cust: 4 to 8 USD*



IT'S NOT ONLY NANOSCIENCE, NANOTECHNOLOGY AND GOOD PUBLIC INICIATIVES

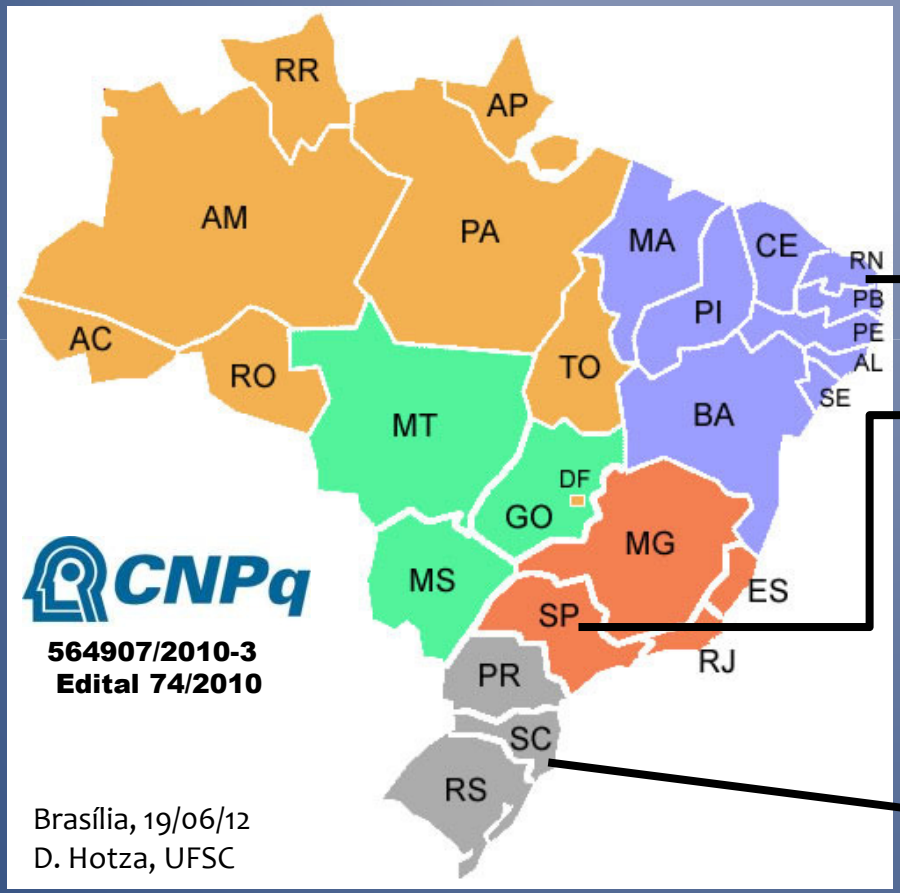
BUSINESS COUNT AS WELL: NEED TO LEAVERAGE ENTREPRENEURSHIP SUPPORTED BY GOVERNMENTAL INITIATIVES

[tata.com, 2011]

- *Tata's group(India)*
  - *Rice husk ash with coloidal Ag*
  - *Water flow: 3-4 l/h; volume: 15-18 l; lifetime: ~3000 l*
  - *Cust: 750-1000 INR (15-20 USD)*

UNDERTAKE NANOTECHNOLOGY EFFORT TO BRING CLEAR WATER TO LOW-INCOME POPULATION

Processing and characterization of functionalized surfaces with antimicrobial nanoparticles for water treatment



CNPq

564907/2010-3
Edital 74/2010

Brasília, 19/06/12
D. Hotza, UFSC

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UNAERP
Universidade de Ribeirão Preto

- Wilson Acchar (UFRN),
- Carlos Rambo (CERMAT/UFSC)
- Cesar Franco (LABSIN/UFSC)
- Cleide Vieira (NUMICAL/UFSC)
- Murilo Innocentini (UNAERP)
- Sonia Mello (IPEN)

UFSC

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INITIAVE AT UFSC: **BIOLOGICAL SAFETY OF BIVALVES MOLLUSC**

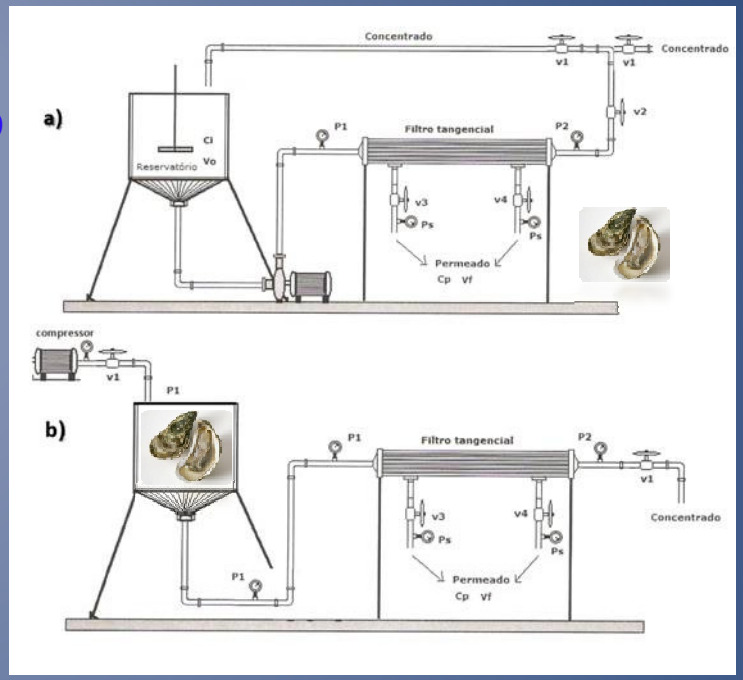
Florianópolis is the largest producer of oyster (*Crassostrea gigas*) in Brasil

CNPq
Conselho Nacional de Desenvolvimento Científico e Tecnológico

An healty economic activity = **SMALL BUSINESSS LARGE ECONOMIC GAIN FOR THE REGION**

EFICIENT BIOLOGIC FILTERS Must kill **pathogenic microorganisms**

LEACHING BIOCIDES TO ENVIRONMENT IS NOT ALLOWED



Escherichia coli
Vibrio parahaemolyticus
Salmonella

RISC TO THE CONSUMERS

SCRUBBLING

Lower bacterias counting present

Classical methods are not efficient:

-Interfere in the sensorial quality of molusculess;

- Low efficiency;

- Interferences.

the application of noble metal nanoparticles for the desinfection in Scrubbling Stations

Functional ceramic composites consisting of a dispersion of silver nanoparticles

THE SEARCH FOR AN EFFICIENT BIOCIDE:

CONTACT vs. MIGRATE BIOCIDES

- *The use of biocide in large scale to fight bio fouling is not eco-friendly*
- *There is an huge effort to produce anti-adherent surface + functionalized with contact biocide*

WHY SILVER?

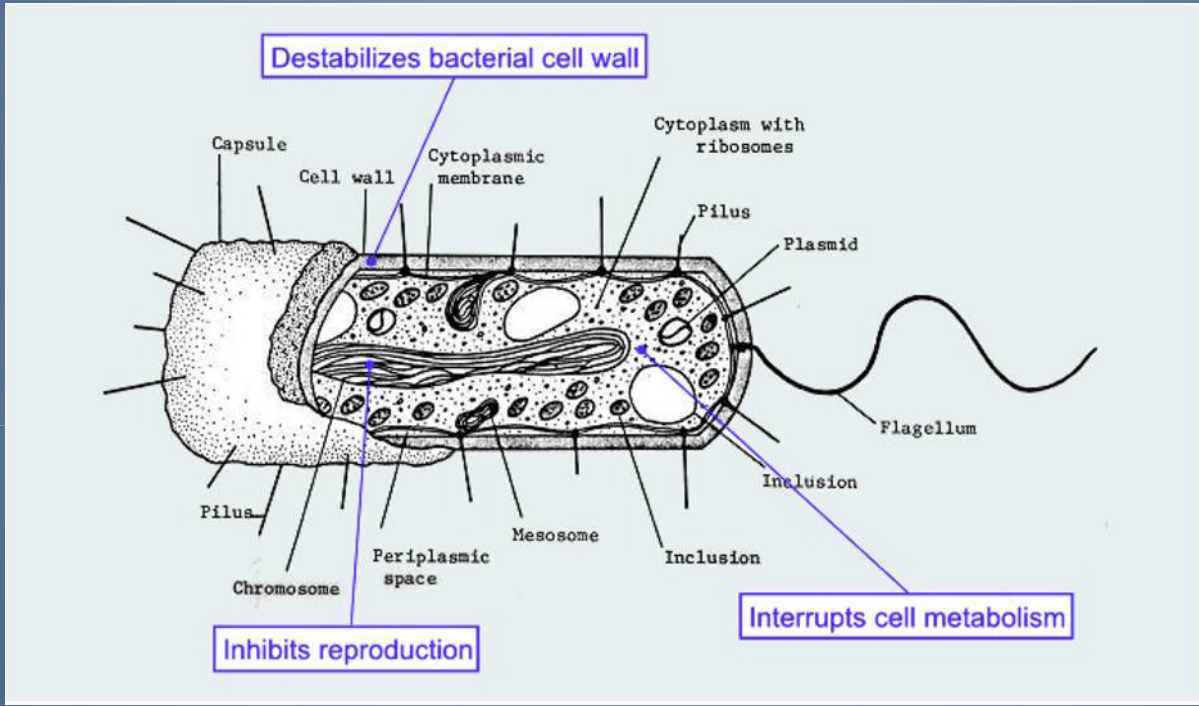
Silver has been known since our ancestors to fight infections.

It reborn with nanotechnology and today leads sales when compared with other nanotechnology products

WHY SILVER? WHAT IT DOES QUITE NICELY IS :

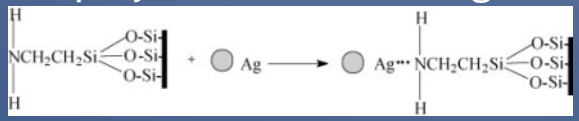
a) Deadly effect of ionic silver avoid bacterial resistance

[Franco, 2011]

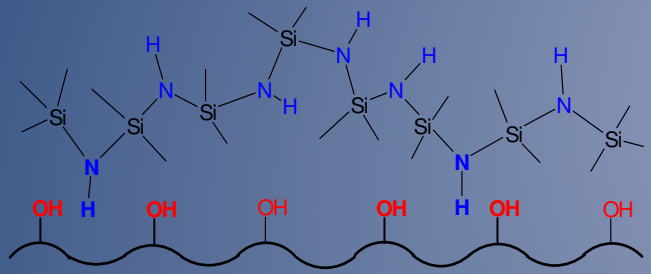


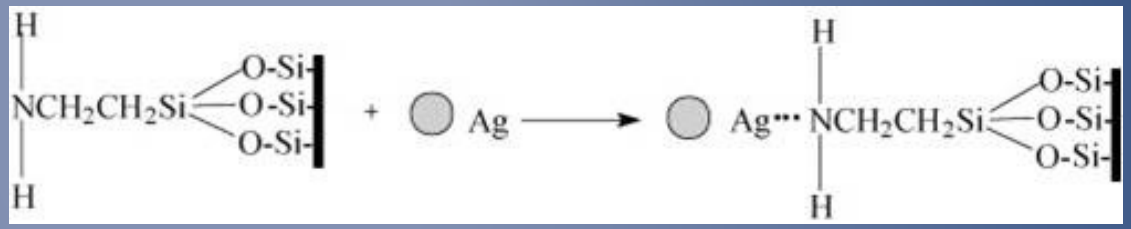
a) Embedded in pre-ceramics (SiCN – Ag)

b) anchoring agents: In the quest to find out novel mechanisms for preventing the release of silver during the process of washing cycles aminosilanes was successfully employed also for design of new filters for potable water purification



There is on more thing: COVALENTLY ANCHORAGE UNITS PROVIDE EFFECTIVE BACTERICIDAL CONTACT





good bactericidal effectiveness and great chemical durability of immobilized Ag nanoparticles

I&EC research
Industrial & Engineering Chemistry Research

Article

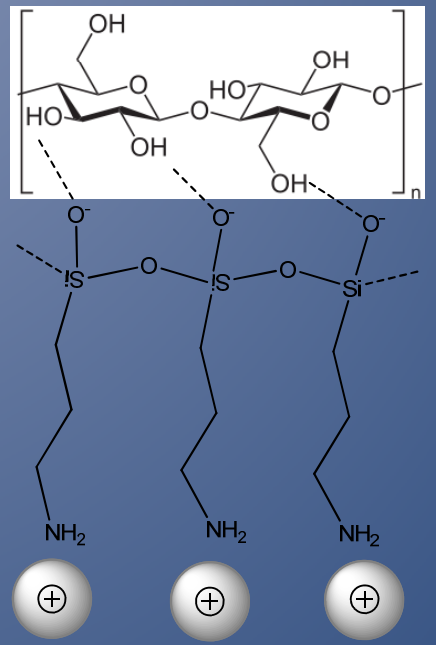
pubs.acs.org/IECR

Synthesis and Characterization of Silver Nanoparticles Produced with a Bifunctional Stabilizing Agent

André L. Nogueira,* Ricardo A. F. Machado, Alan Z. de Souza, Flávia Martinello,† César V. Franco,‡ and Gabriel B. Dutra§

Department of Chemical Engineering, Federal University of Santa Catarina (UFSC), Campus Universitário Trindade, Caixa Postal 476, 88040-900, Florianópolis, Santa Catarina, Brazil

ABSTRACT: Among the different chemical compounds used to prevent the aggregation and to control the size of silver nanoparticles, the aminosilanes are interesting because they can simultaneously act as stabilizing and coupling agents. The aim of this study was to investigate the effects of different concentrations of an aminosilane on the synthesis of silver nanoparticles. The functionalized nanoparticles were characterized using UV−vis spectrophotometry, transmission electron microscopy (TEM), selected area electron diffraction (SAED), X-ray diffraction (XRD), and zeta (ζ) potential. Antibacterial assays were also performed. According to the results, increasing the concentration of the aminosilane produced smaller, less dispersed, and more stable silver nanoparticles. Besides the effective antibacterial activity verified in all the concentrations tested, a significant influence on the kinetics of bacteria annihilation was also observed when aminosilane was used in a concentration dependent fashion. These findings indicated the important effects of aminosilane concentrations in controlling the size and stability of the colloids, as well as the rate of silver ions releasing from nanoparticles.

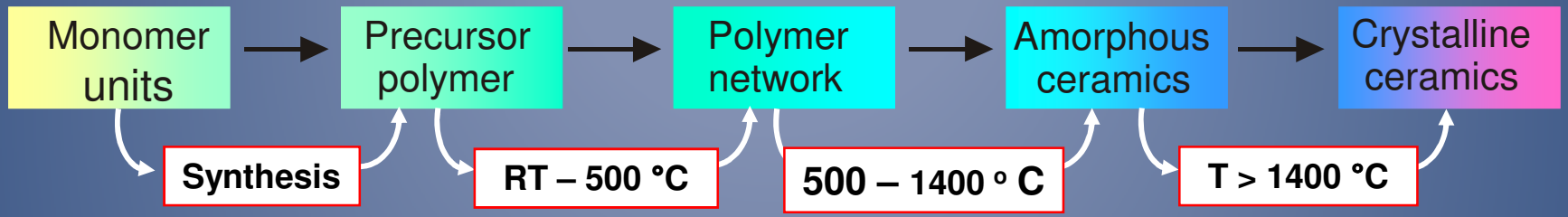


Ind. Eng. Chem. Res., **2014**, 53 (9), pp 3426−3434

FUNCTIONALIZED COATINGS: Use of polymer derived ceramics for introducing functional nanoparticles as fillers for highly effective coatings.

Synergistic effect vs. sterilizing effect

General way from preceramic polymer to precursor-derived ceramic



Advantages

- flexible shaping process
- use of functional nanoparticles as fillers

Limitations

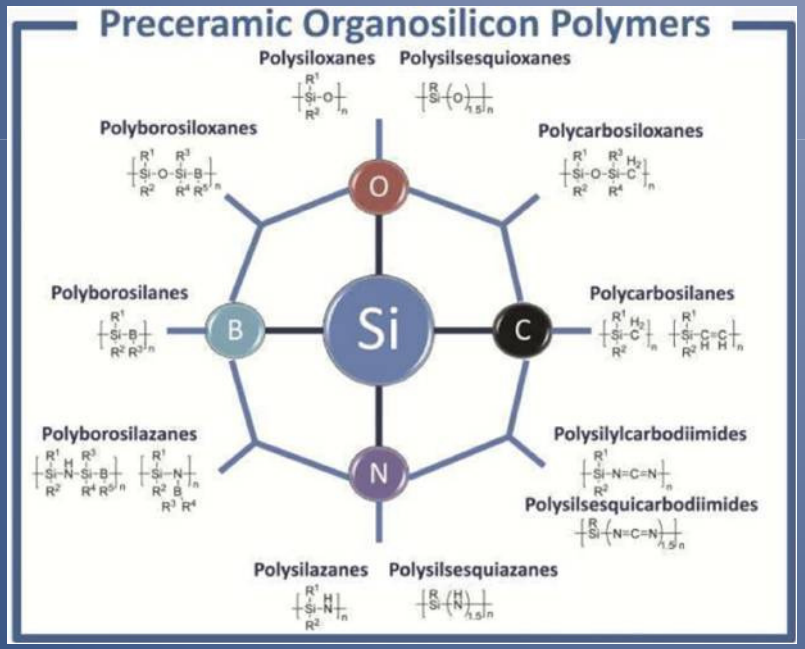
- polymer shrinkage up to 50 %
- use of organic solvents

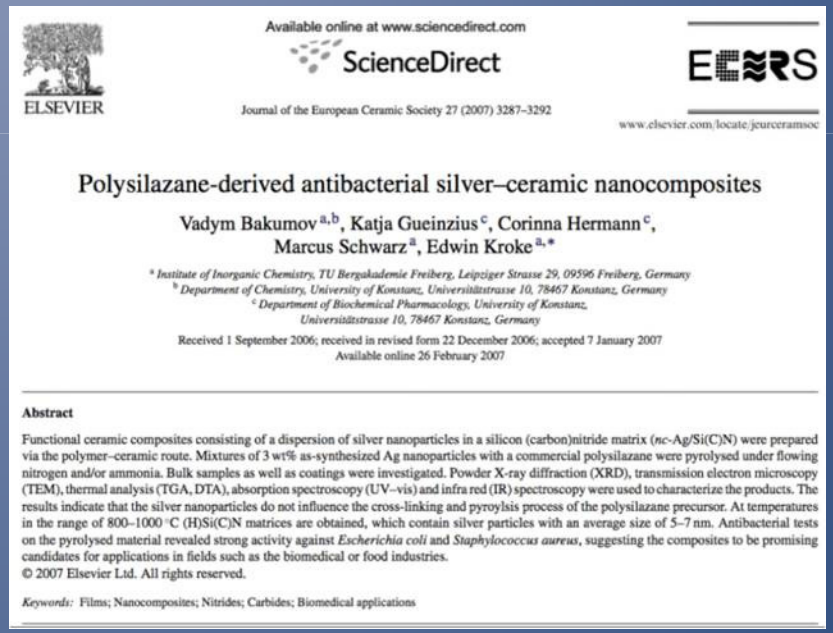
Applications

- Corrosion/oxidation protection
- High temperature/pressure
- Functional coatings
- Nanofillers

POLYSILAZANE-DERIVED ANTIBACTERIAL SILVER–CERAMIC NANOCOMPOSITES

- *There is an huge effort to produce anti-adherent surface (synergistic) + functionalized with contact biocide (sterilizing)*





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Journal of the European Ceramic Society 27 (2007) 3287–3292
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Polysilazane-derived antibacterial silver–ceramic nanocomposites

Vadym Bakumov [a,b], Katja Gueinzius [c], Corinna Hermann [c], Marcus Schwarz [a], Edwin Kroke [a,*]

[a] Institute of Inorganic Chemistry, TU Bergakademie Freiberg, Leipziger Strasse 29, 09596 Freiberg, Germany
[b] Department of Chemistry, University of Konstanz, Universitätstrasse 10, 78467 Konstanz, Germany
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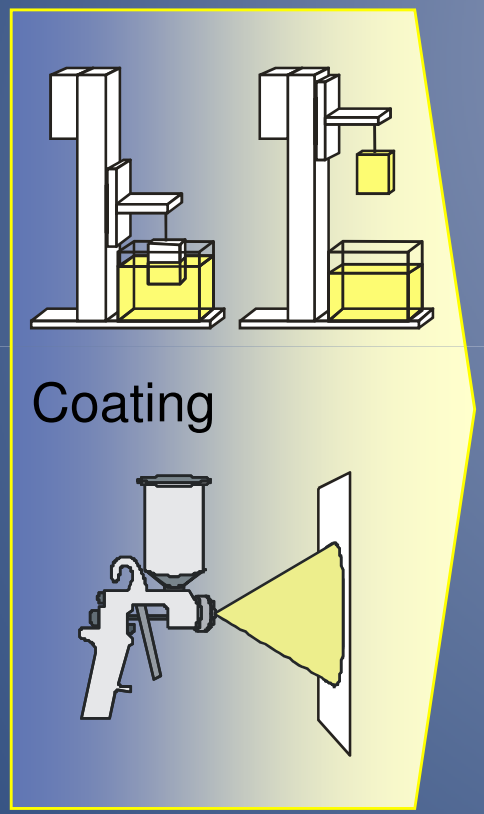
Received 1 September 2006; received in revised form 22 December 2006; accepted 7 January 2007
Available online 26 February 2007

Abstract

Functional ceramic composites consisting of a dispersion of silver nanoparticles in a silicon (carbon)nitride matrix (*nc*-Ag/Si(C)N) were prepared via the polymer–ceramic route. Mixtures of 3 wt% as-synthesized Ag nanoparticles with a commercial polysilazane were pyrolysed under flowing nitrogen and/or ammonia. Bulk samples as well as coatings were investigated. Powder X-ray diffraction (XRD), transmission electron microscopy (TEM), thermal analysis (TGA, DTA), absorption spectroscopy (UV–vis) and infra red (IR) spectroscopy were used to characterize the products. The results indicate that the silver nanoparticles do not influence the cross-linking and pyroylsis process of the polysilazane precursor. At temperatures in the range of 800–1000 °C (H)Si(C)N matrices are obtained, which contain silver particles with an average size of 5–7 nm. Antibacterial tests on the pyrolysed material revealed strong activity against *Escherichia coli* and *Staphylococcus aureus*, suggesting the composites to be promising candidates for applications in fields such as the biomedical or food industries.

Keywords: Films; Nanocomposites; Nitrides; Carbides; Biomedical applications

PROCESSING OF PRECERAMICS COATINGS TO MITIGATE BIOFOULING



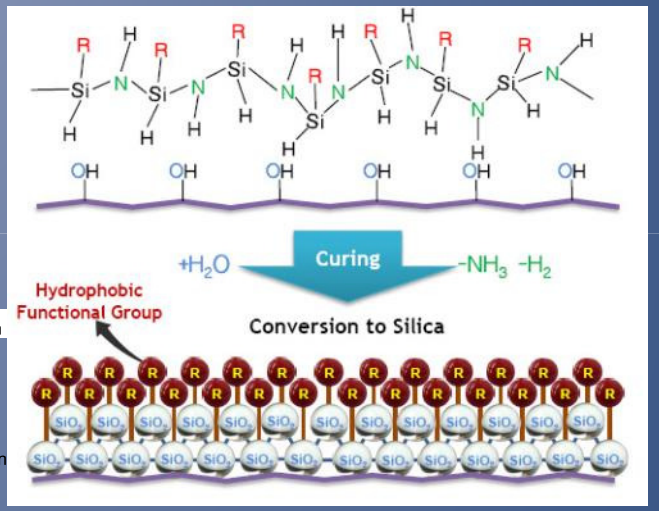
up to 500 °C

Pyrolysis

polymer derived ceramics (PDCs)

Drying

Monomer Unit
Synthesis
Precursor Polymer / Oligomer
Crosslinking
Preceramic Network
Ceramization
Amorphous Covalent Ceramic
Crystallization
Crystalline Covalent Ceramic



Pyrolysis

up to 1200 °C

Dip-coated steel sheet
Pyrolysis at 1000 °C in N_2

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Film of TiO_2/SiO_2 SYNERGISTIC EFFECT

- Best hydrophilicity and better self-cleaning effect with SiO_2
- Hydrophilicity is probably more important than the photocatalysis for the self-cleaning effect

[Guam, 2005]

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Surface & Coatings Technology 191 (2005) 155–160
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Relationship between photocatalytic activity, hydrophilicity and self-cleaning effect of TiO_2/SiO_2 films

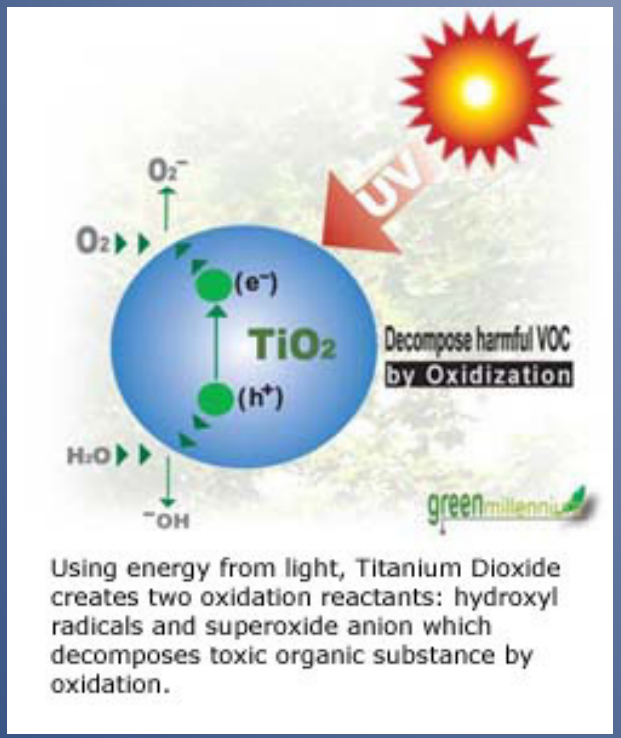
Kaishu Guan*

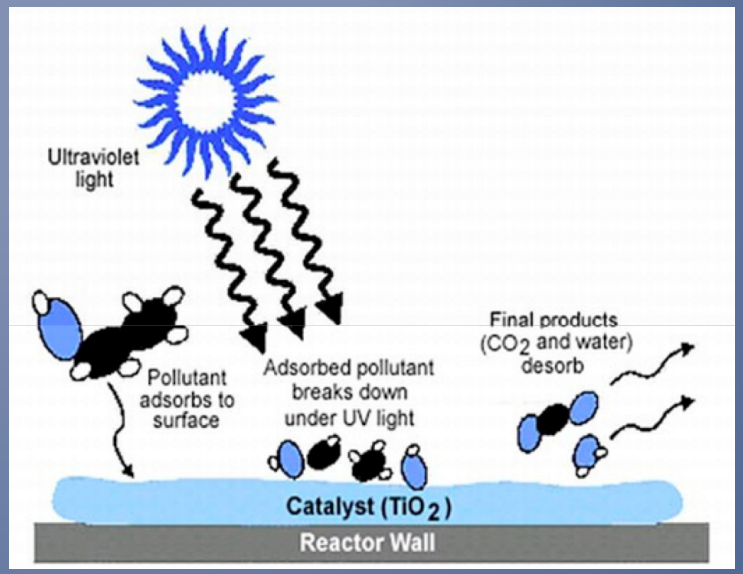
Research Institute of Process Equipment, East China University of Science and Technology, 130 Meilong Road, Box 402, Shanghai 200237, China

Received 20 May 2003; accepted in revised form 17 February 2004

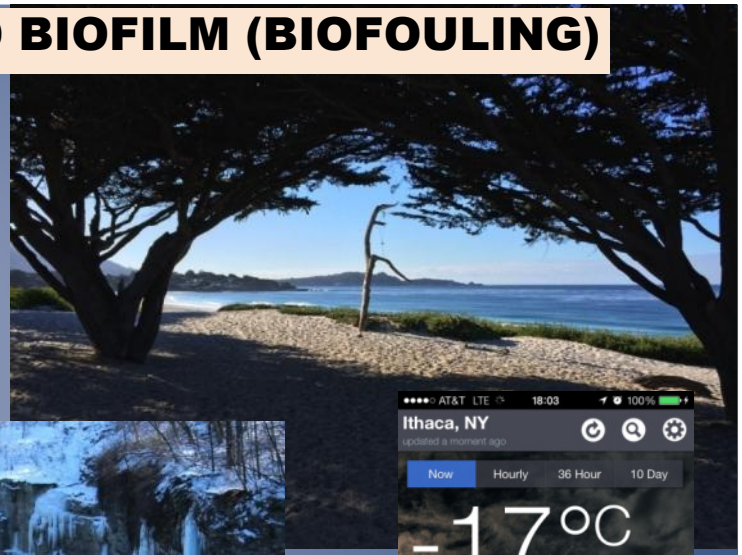
Film of TiO_2/SiO_2 UNDER ILUMINATION

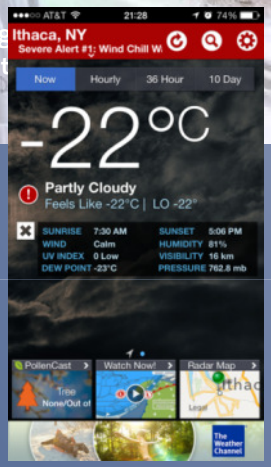
- *Properties of Photocalytic Surfaces (UV activated functionalities)*
  - *Decomposition of organic materials*
  - *Wettability enhancement*
  - *Allow for wash water*





QUORUM SENSING MECHANISM TO AVOID BIOFILM (BIOFOULING)





WHAT MOTIVATE SOMEONE TO REPLACE A SUMMER SEASON BY A HARSH WINTER??

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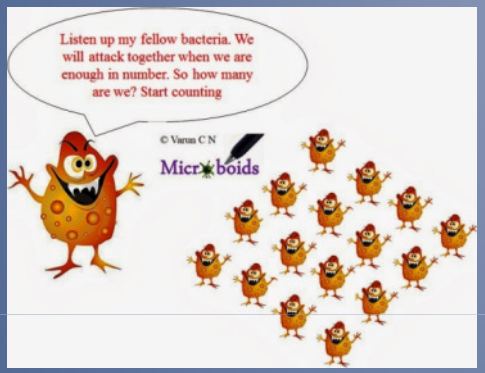
UFSC
LabSIN
Laboratório de Síntese Inorgânica e Nanocompósitos

- THE BACTERIAS -

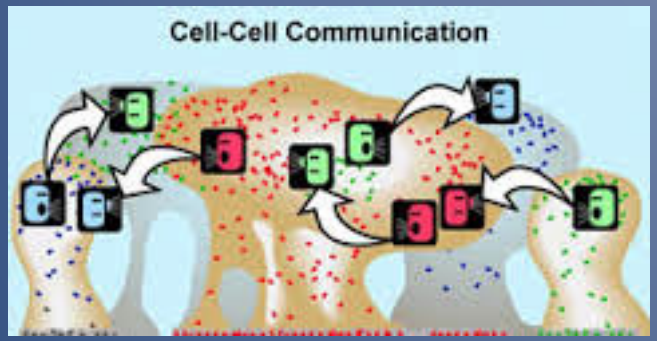
WHAT WILL HAPPEN IF WE USE QUORUM SENSING MECHANISM TO AVOID BIOFILM (BIOFOULING)

What fascinates us in bacteria is that they have a very sophisticated system of communication.



QUORUM SENSING: They know when they are in sufficient numbers to attack and become virulent

They talk among them and the most amazing, talk to our human cells



In the language of bacteria, the words are small molecules and with the knowledge we have it is possible to interfere. This is a kind of interesting!

ANTI QUORUM SENSING: some substances likely to cause interference in the communication of bacteria.

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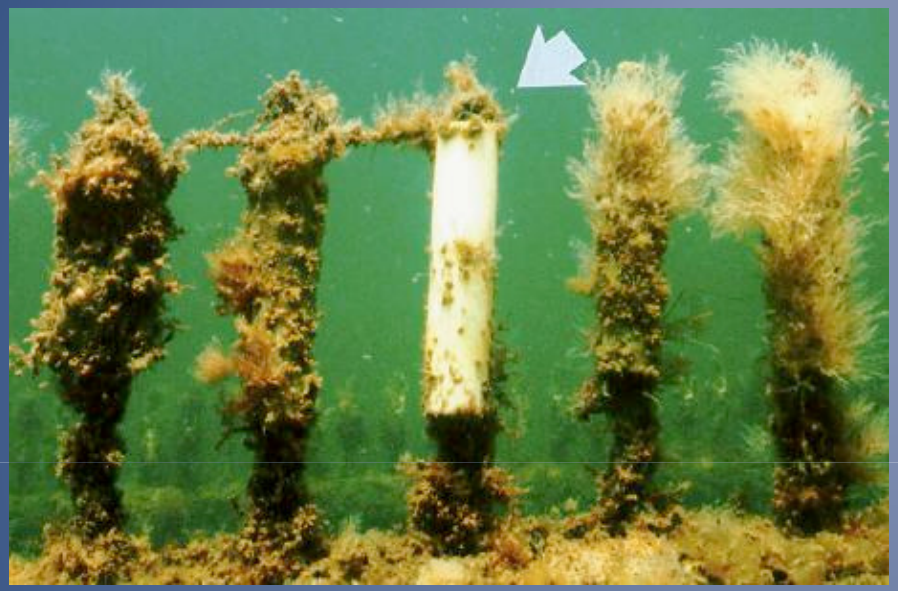
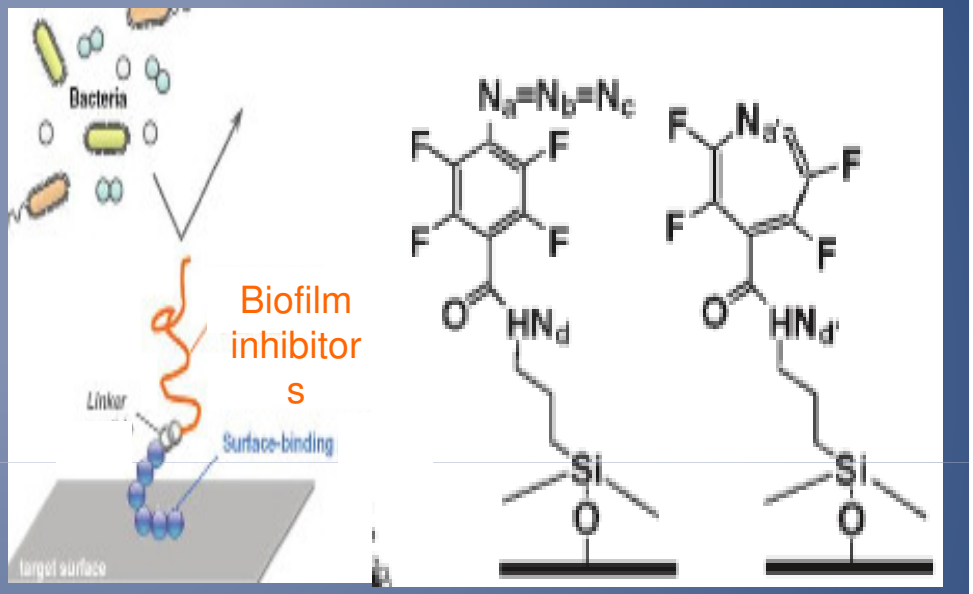
How can we do this effectively? – **Furanone - silane**

We are examinig here is use of **PHPS Nanocoatings containing biofilm inhibitors**





The Australian red marine alga *Delisea Pulchra* produces halogenated furanones to prevent fouling by micro- and macro-organisms in marine environments.

The furanone derivatives are encapsulated in vesicles in specialized gland cells and located both in the interior and on the surface of the plant.

Covalent Immobilization of Antibacterial Furanones via Photochemical Activation of Perfluorophenylazide

Sameer A. Al-Bataineh,*,†,⊥ Reto Luginbuehl,‡ Marcus Textor,† and Mingdi Yan§

†*Laboratory for Surface Science and Technology, Department of Materials, ETH Zürich, CH-8093 Hönggerberg, Switzerland,* ‡*RMS Foundation, CH-2544 Bettlach, Switzerland, and* §*Department of Chemistry, Portland State University, PO Box 751, Portland, Oregon 97207.* ⊥*Current address: Mawson Institute, University of South Australia, Mawson Lakes 5095, Australia*

Received January 27, 2009. Revised Manuscript Received April 1, 2009

N-(3-Trimethoxysilylpropyl)-4-azido-2,3,5,6-tetrafluorobenzamide (PFPA-silane) was used as a photoactive cross-linker to immobilize antibacterial furanone molecules on silicon oxide surfaces. This immobilization strategy is useful, especially for substrates and molecules that lack reactive functional groups. To this end, cleaned wafers were initially incubated in solutions of different concentrations of PFPA-silane to form a monolayer presenting azido groups on the surface. The functionalized surfaces were then treated with a furanone solution followed by illumination with UV light and extensive rinsing with ethanol to remove noncovalently adhered molecules. In the presented study, we demonstrate the ability to control the surface density of the immobilized furanone molecules by adjusting the concentration of PFPA-silane solution used for surface functionalization using complementary surface analytical techniques. The fluorine in PFPA-silane and the bromine in furanone molecules were convenient markers for the XPS study. The ellipsometric layer thickness of the immobilized furanone molecules on the surface decreased with decreasing PFPA-silane concentration, which correlated with a decline of water contact angle as a sign of film collapse. The intensity of characteristic azide vibration in the MTR IR spectra was monitored as a function of PFPA-silane concentration, and the peak disappeared completely after furanone application followed by UV irradiation. As a complementary technique to XPS, TOF-SIMS provided valuable information on the chemical and molecular structure of the modified surfaces and spatial distribution of the immobilized furanone molecules. Finally, this report presents a convenient, reproducible, and robust strategy to design antibacterial coating based on furanone compounds for applications in human health care.

So based on this **Anti - quorum sensing covalently attached**

To imobilized PFPA prevent biofilm formation

Al-Bataineh et al.

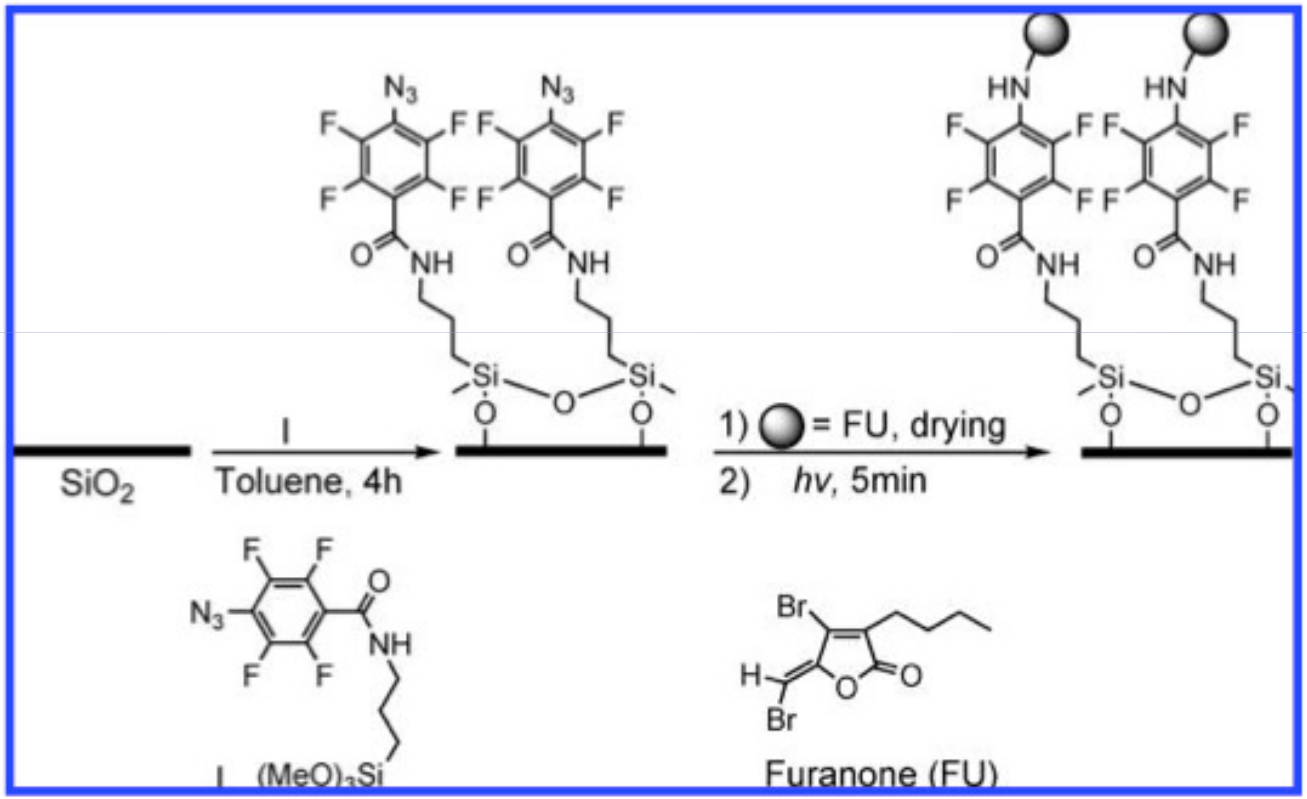


Figure 1. Covalent immobilization of furanone molecules on PFPA-functionalized surface.

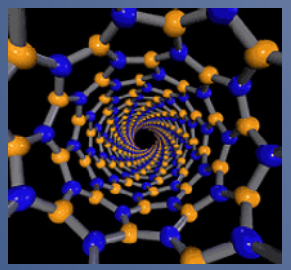
ELECTROSPUN NANOFIBERS EMBEDDED WITH ANTI QUORUM SENSING COMPOUNDS

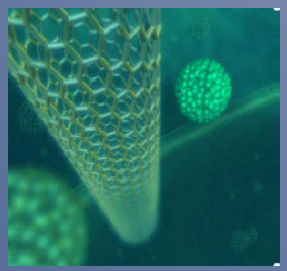
1st Brazil-China Seminar on Nanotechnology

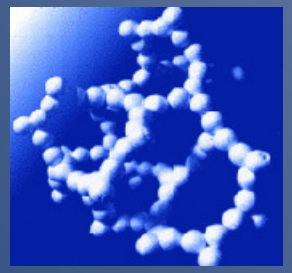
LCP – Process Control Laboratory

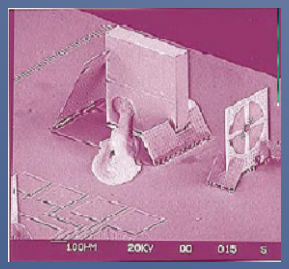
Prof. Ricardo A. F. Machado
Coordinator

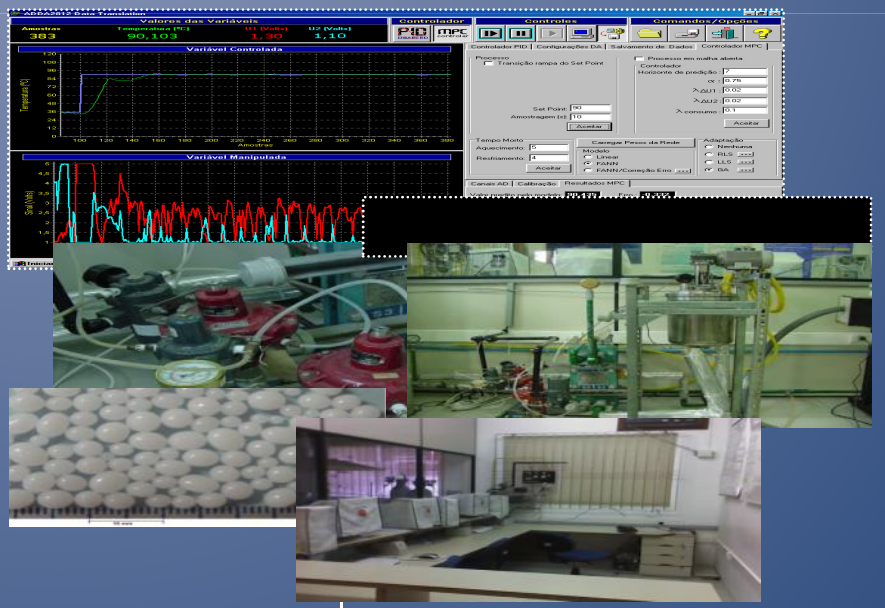
- Nanomaterials: Preparation and Characterization (Polymeric Materials)
- Application for Information Materials and Devices
- Application for Functional Materials (Petroleum and Gas Industry)
- Hybrid Materials (Organic-Inorganic Polymers) Nanodevices and nanotubes
- Process Scale Up, Dynamic, Optimization and Automatic Control





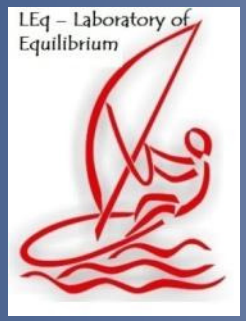






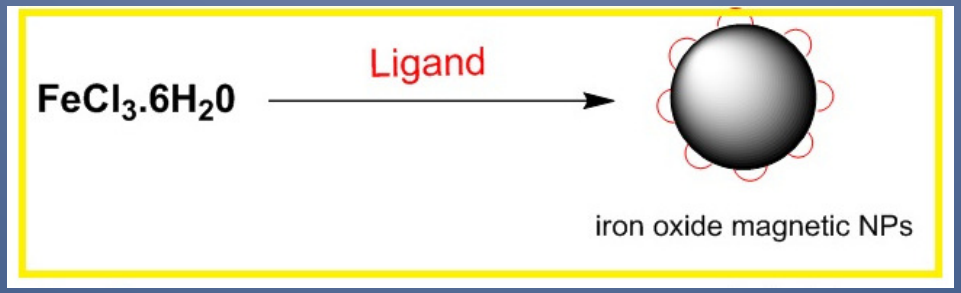
O LINDEN TEM O *i* DA *inovação*

LEq – Laboratory of Equilibrium

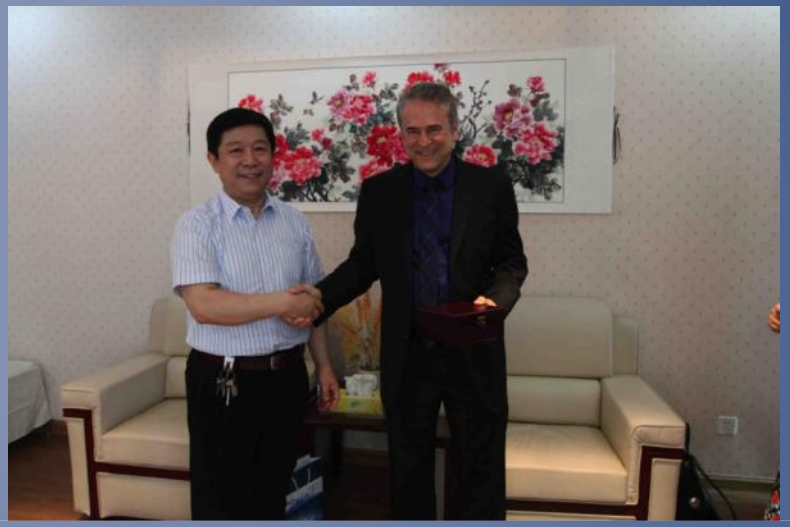


Prof. Dr. Bruno Szpoganicz
Coordinator

- Synthesis of iron oxide nanoparticles stabilized by biopolymers
- Equilibrium measurements of interactions of polymers and divalent metal ions.



NERCN – UFSC Partnership



NERCN – UFSC Partnership