On the path forward to biomedical applications of natural polyfunctional compounds - humic substances

Irina V. Perminova

Department of Chemistry
Lomonosov Moscow State University, Moscow, Russia

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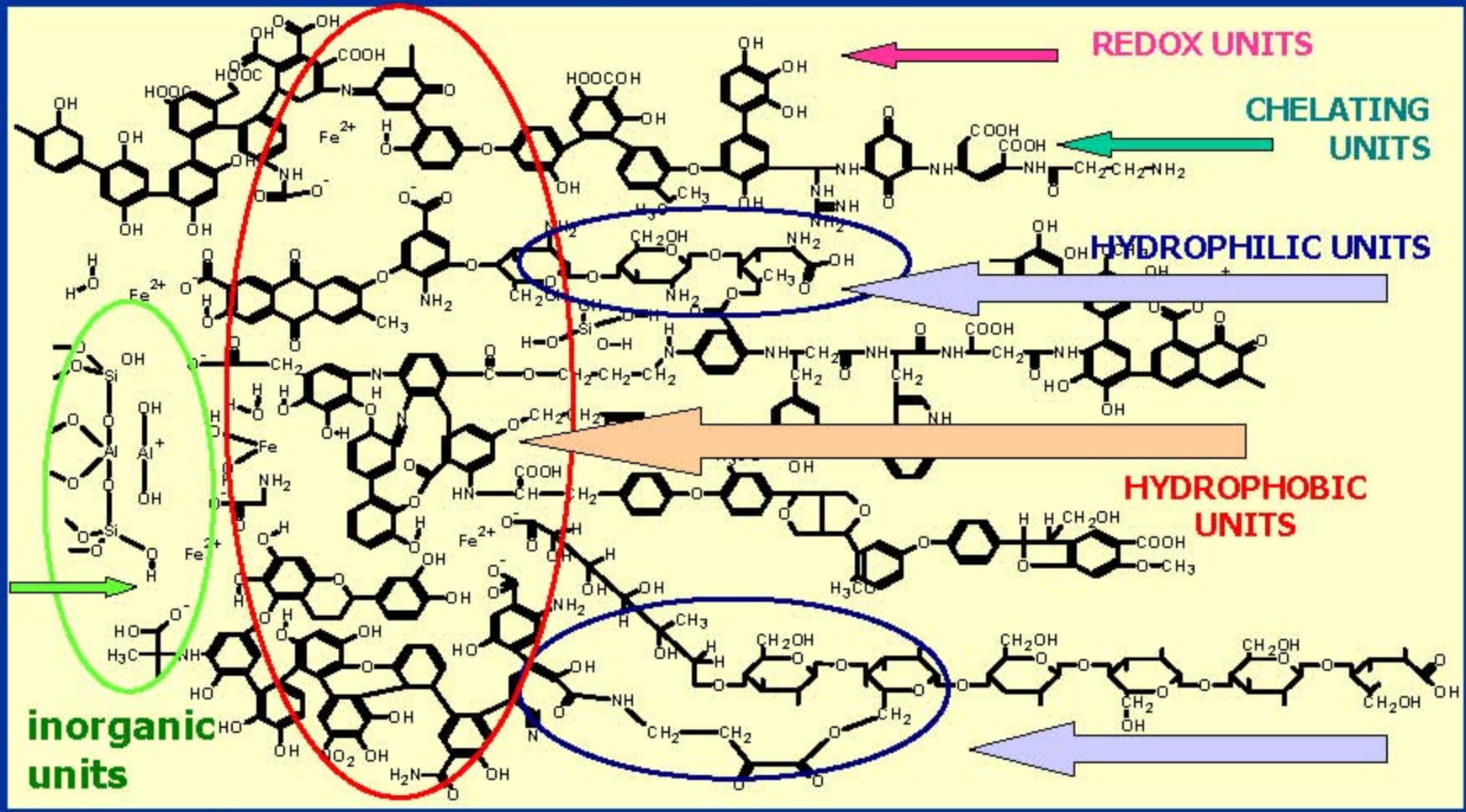
HiT 2010 Conference

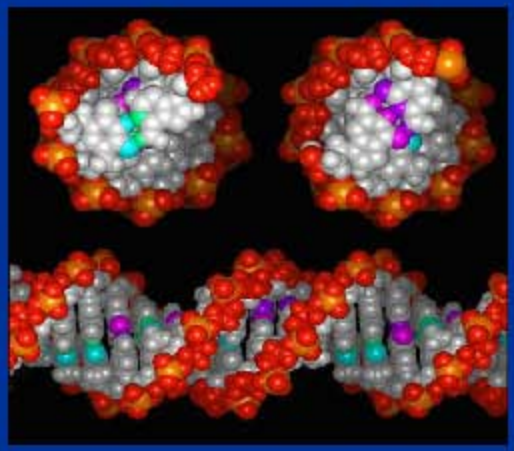
HUMIC MOLECULES: KINGDOM OF FUNCTIONS



EARTH, IN LATINE - HUMUS…

Humus – coevolution product of living and non-living matter

FORMATION OF HUMICS: DECOMPOSITION OF LIVING MATTER



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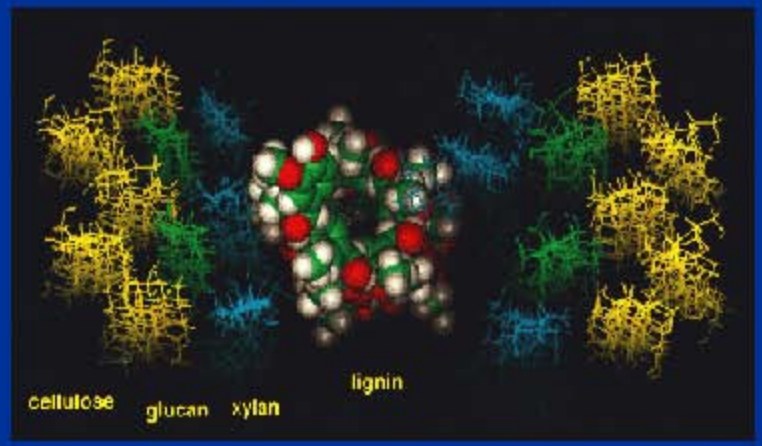

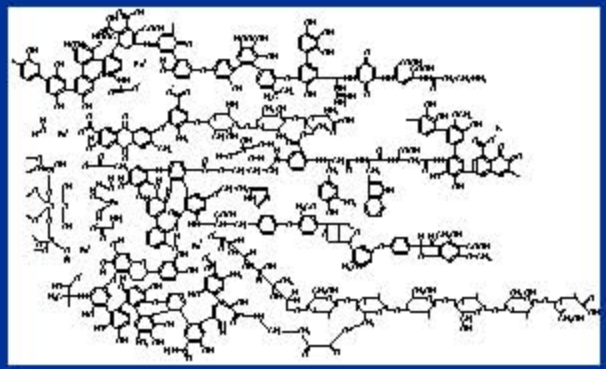

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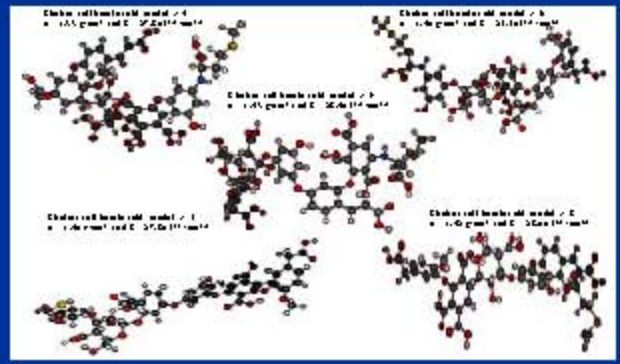
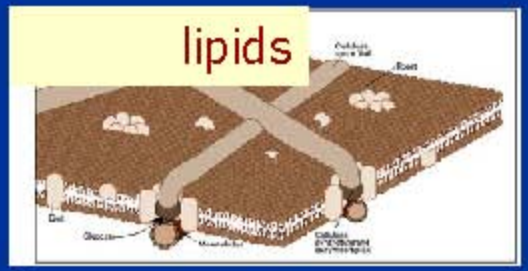


+

CO_2, H_2O
NO_3^-, SO_4^{2-}
PO_4^{3-}

HUMIFIED BIOMASS

TYPE OF BOMASS AND CONDITIONS - IMPACT ON STRUCTURE OF HUMICS



Aromaticity

Lipids

Sugars

Coal

Soil

Sapropel

Peat

Compost

Water

WHY HUMIC SUBSTANCES?

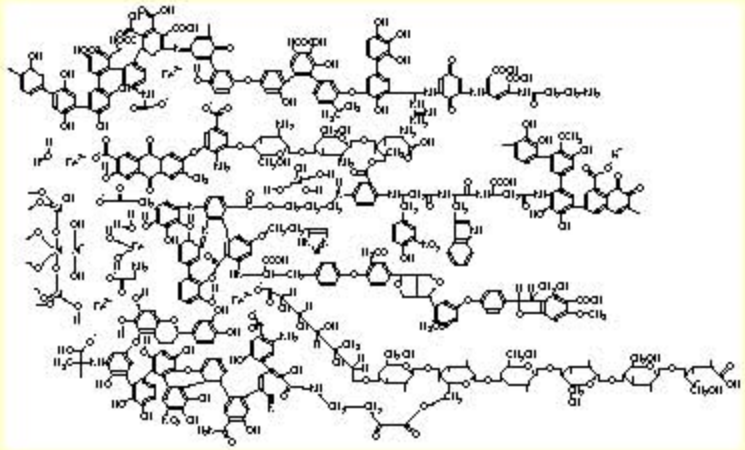
UNIQUE CHEMICAL AND BIOLOGICAL PROPERTIES

- polyfunctional, extended carbon backbone, surface active
- bioadaptogenic, biocompatible, non-toxic, refractory

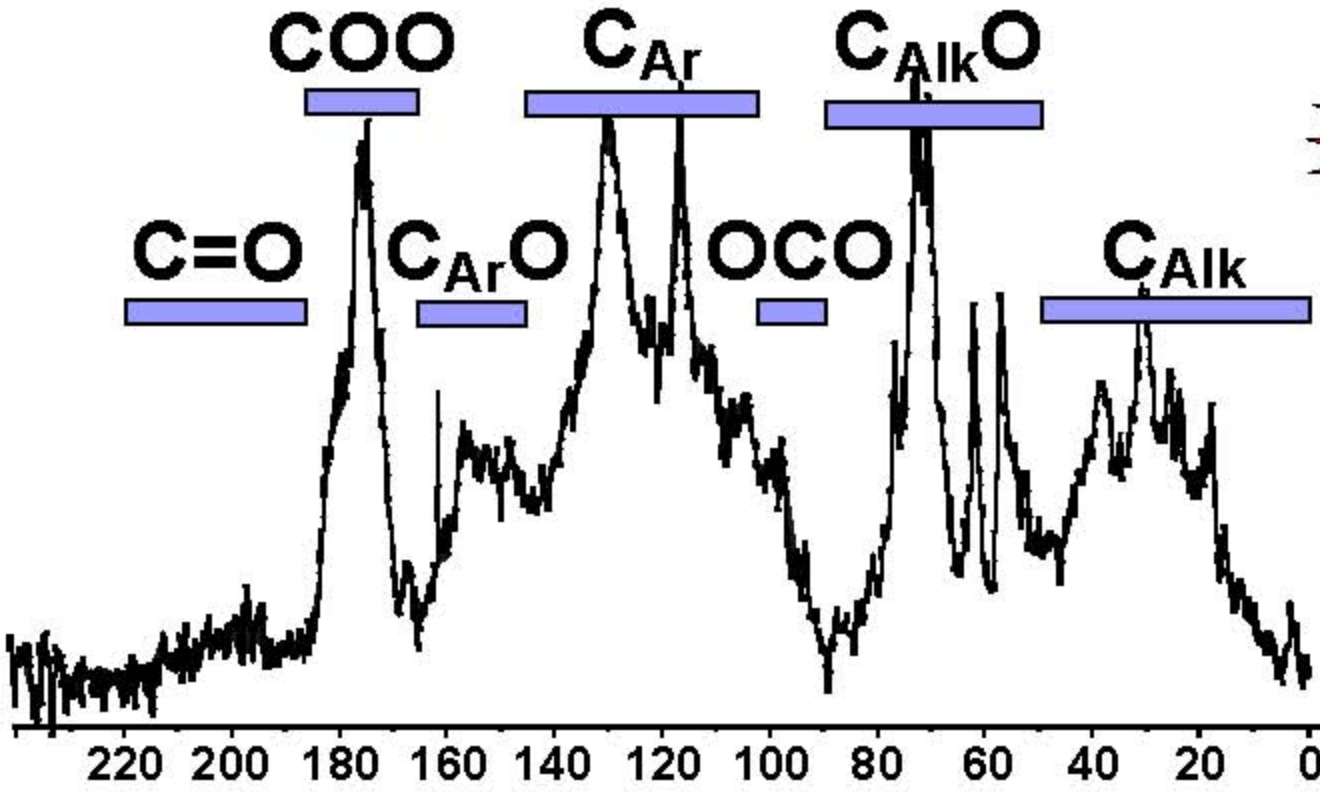
WHAT IS A MAIN CHALLENGE?

NATURE'S MOST COMPLEX ORGANIC MATERIALS

- **extreme structural heterogeneity** translates into properties that are difficult to control
- **quality criteria are missing**



Typical ^{13}C NMR Spectrum of HS



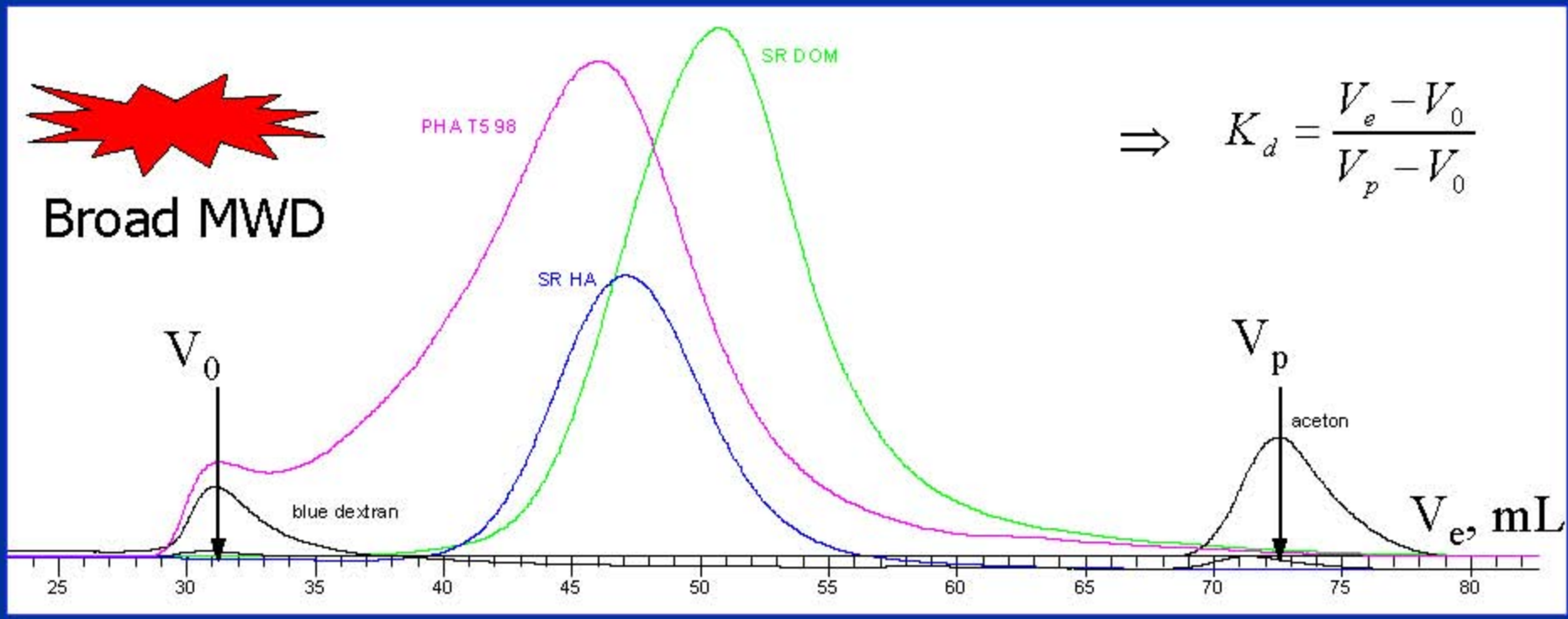
Highly overlapped resonances

- High hetero-geneity

Descriptors of structural-group composition (C, %):

$C=O$, COO, $C_{Ar}O$, C_{Ar}, OCO, $C_{Alk}O$, C_{Alk}

MOLECULAR WEIGHT DISTRIBUTION OF HUMICS: HIGH POLYDISPERSITY

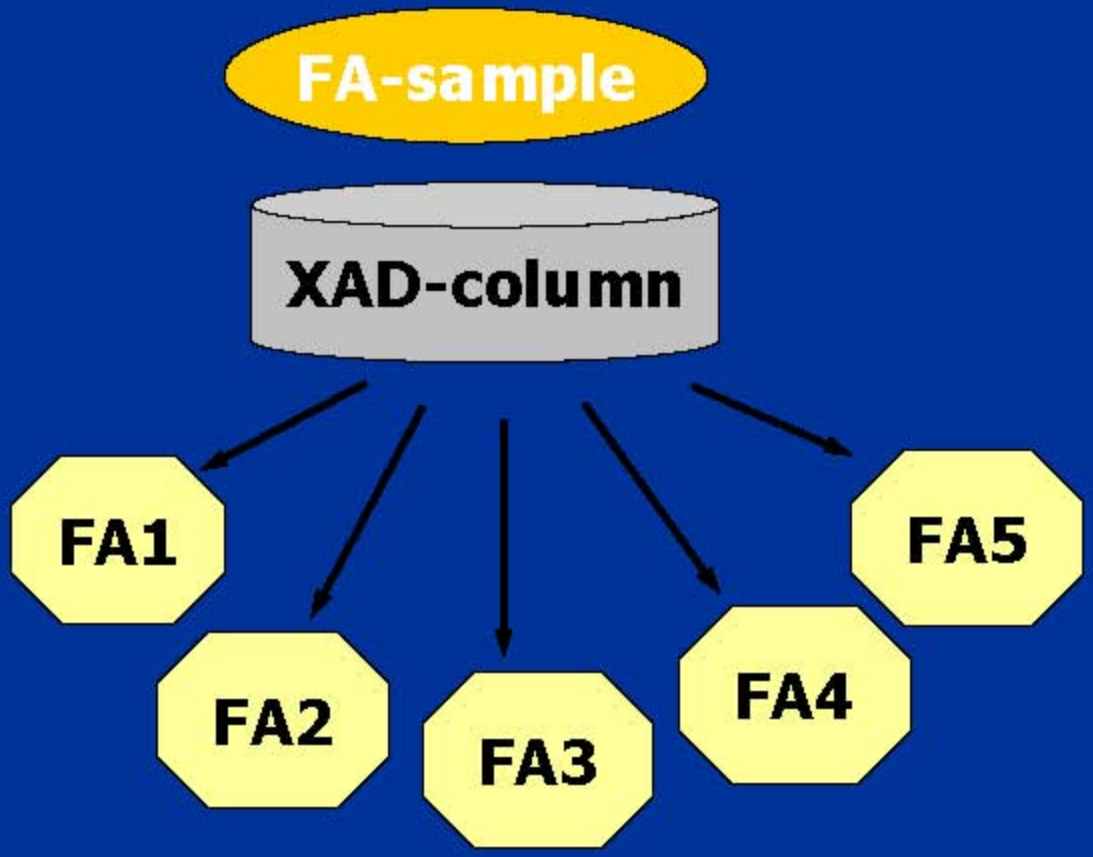


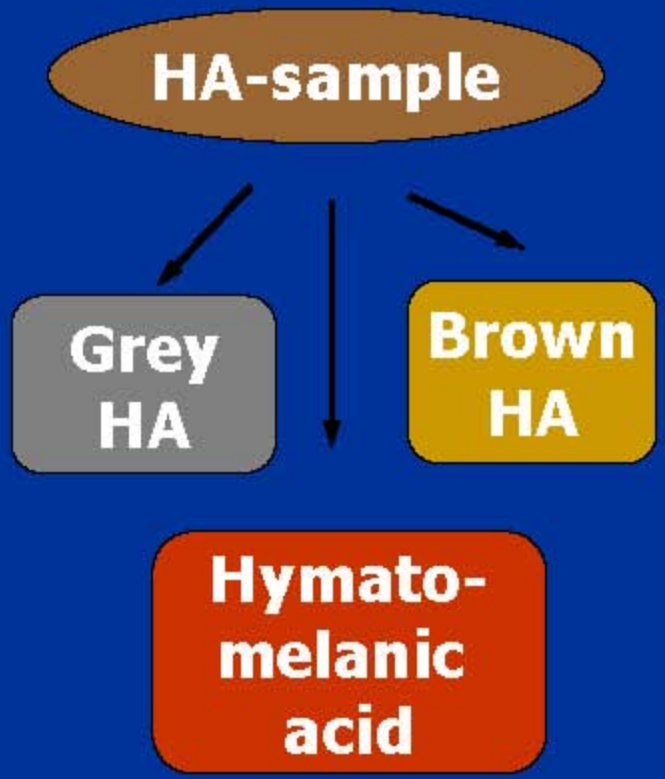
Gel: Toyopearl HW-55S

Mobile phase: 0.028 M phosphate buffer, pH 6.8

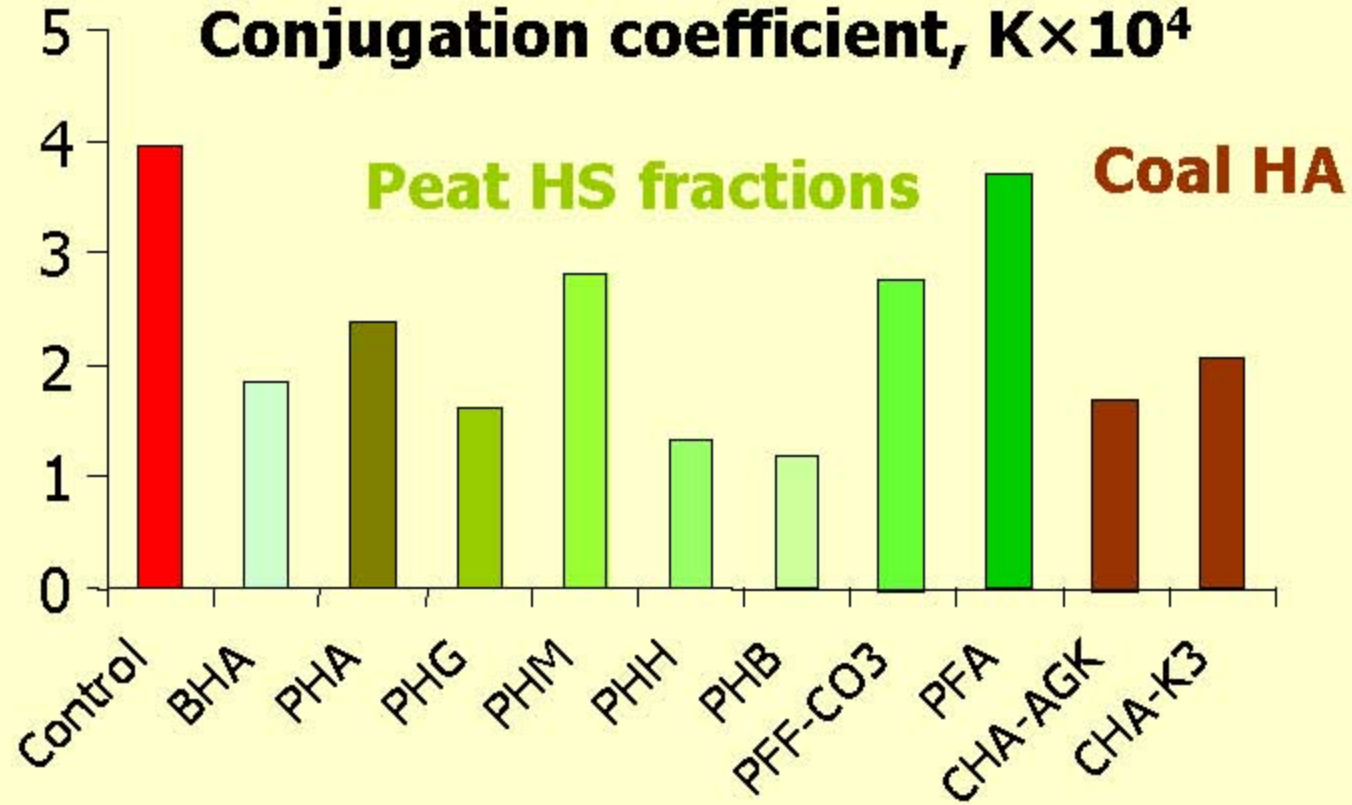
HS concentration: 20-50 mg C/L, Detection: UV

FRACTIONATION OF HS

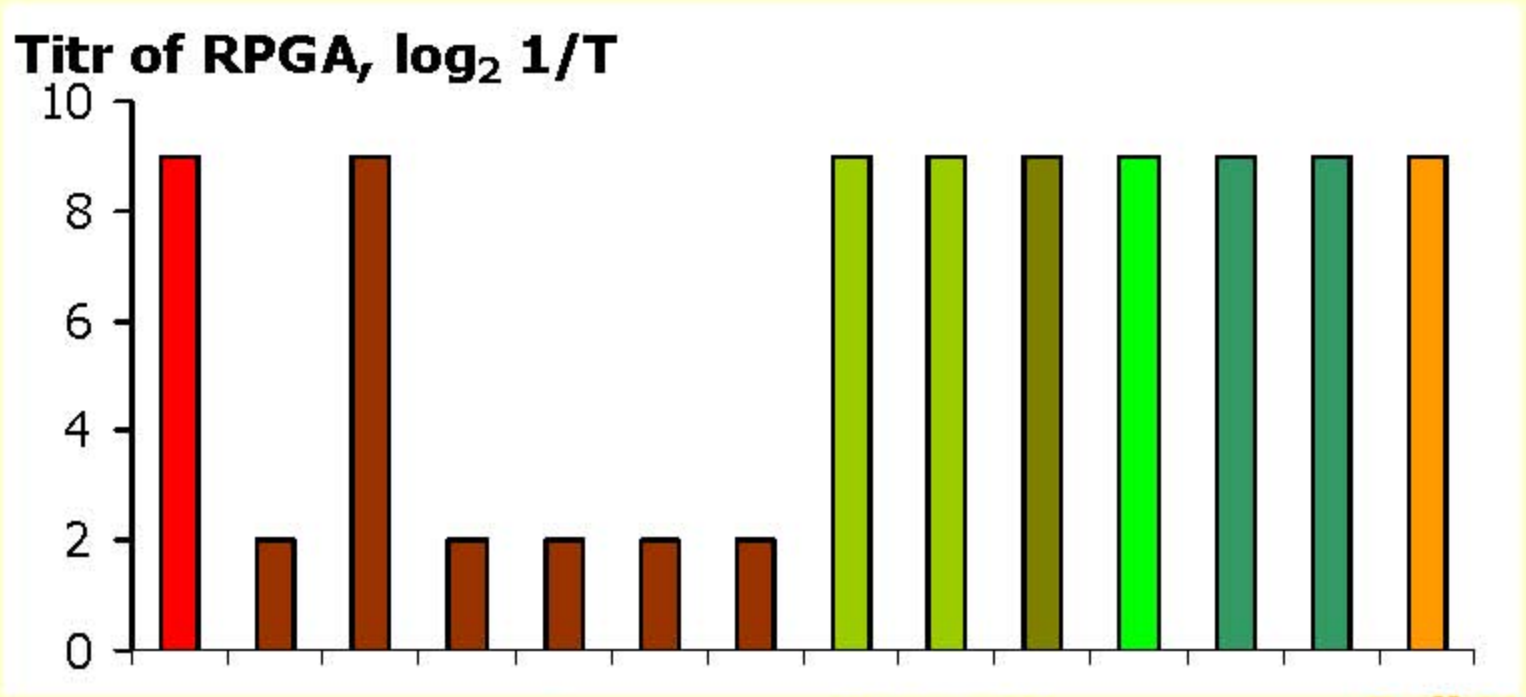




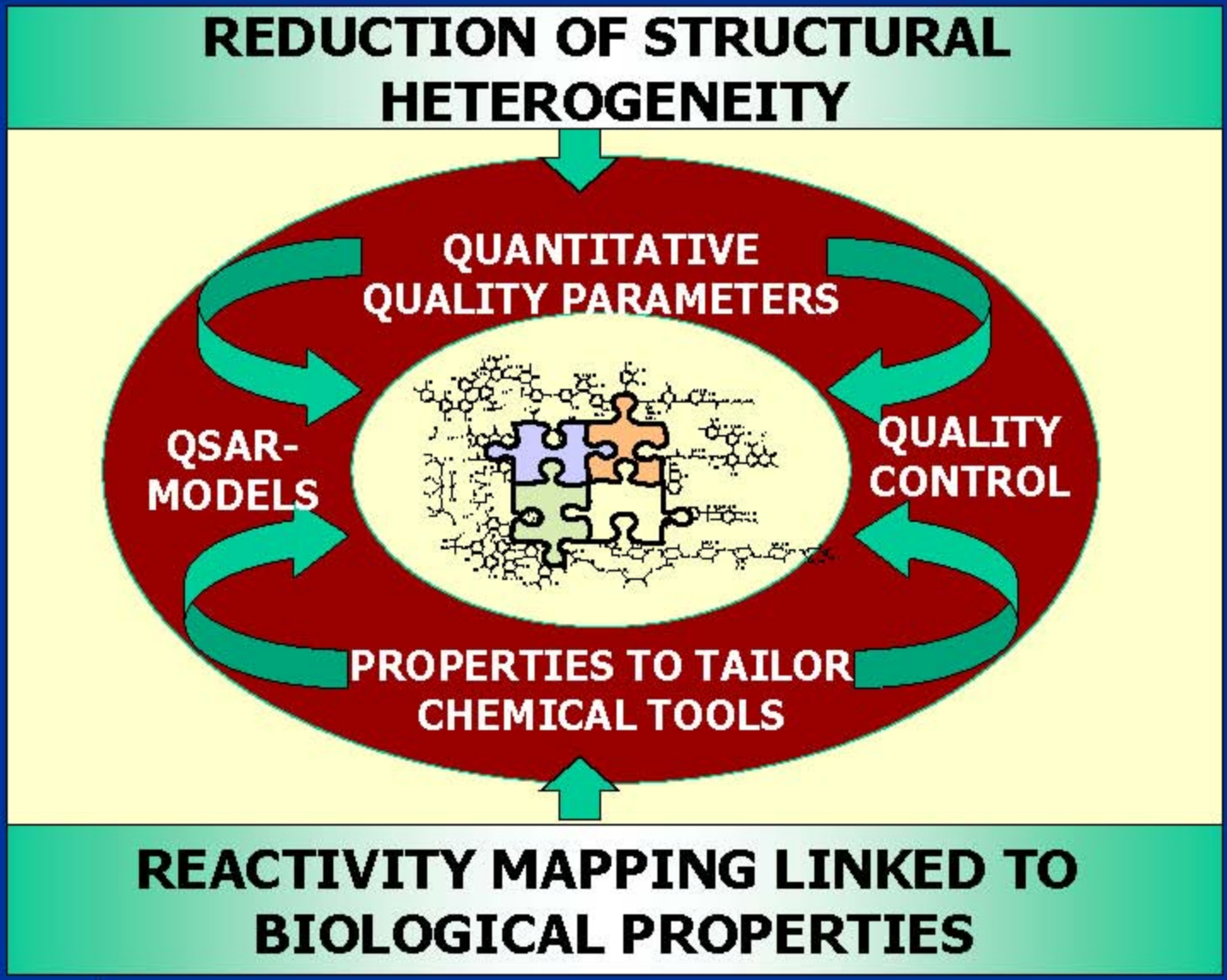
Influence of the HS fractions on the transfer of *F*- plasmide



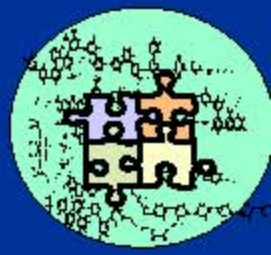
Influence of HS fractions on sorption of endotoxin (LPS) on the erithrocites



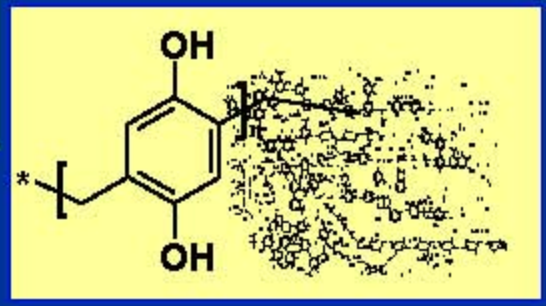
CONCEPT OF "DESIGNER HUMICS"



THE PROPOSED SYNTHETIC STRATEGIES

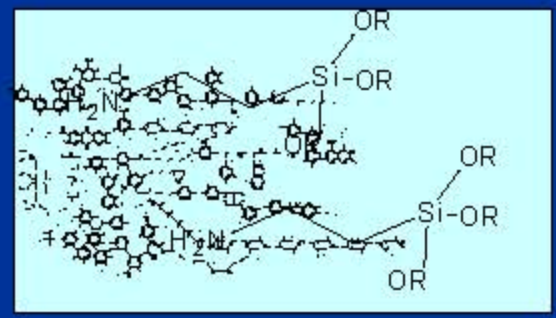


TAILORING FUNCTIONAL MOLECULES AND MATERIALS



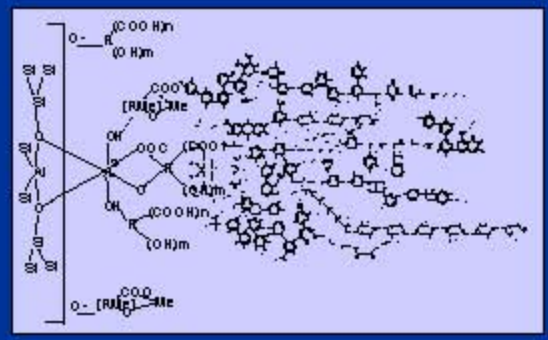
POLYCONDENSATION WITH DESIRED MONOMERS – HUMIC GRAFT-COPOLYMERS

DERIVATIZATION OF HUMIC MACROMOLECULES – HUMIC DERIVATIVES



TAILORING HYBRIDE MATERIALS

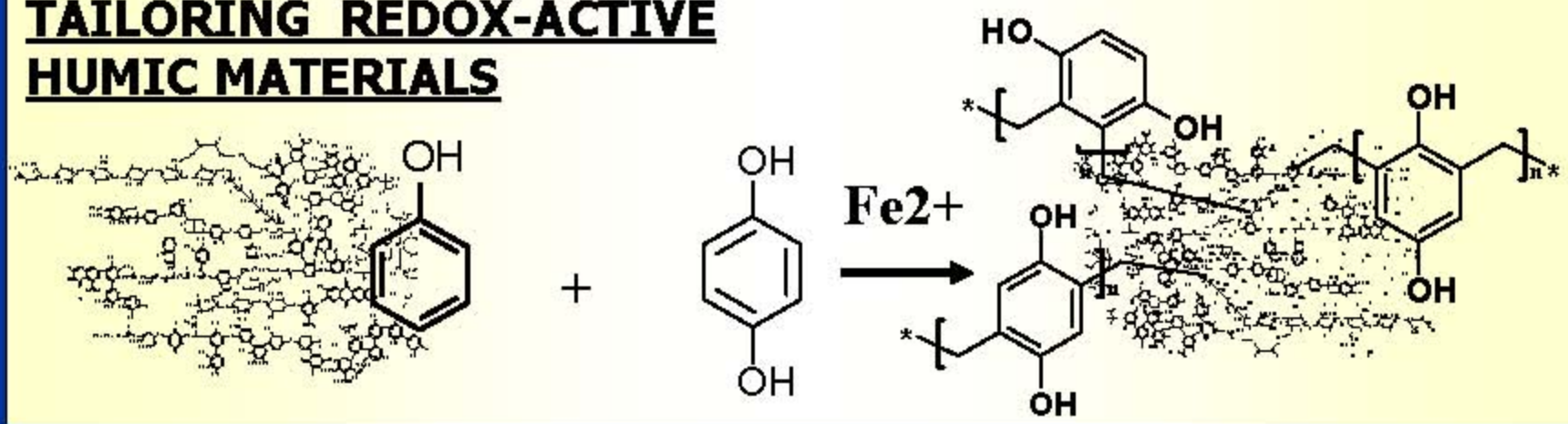
IMPLANTING ONTO MINERAL SUPPORT – SYNTHESIS OF HUMIC COATINGS AND HYBRID MATERIALS



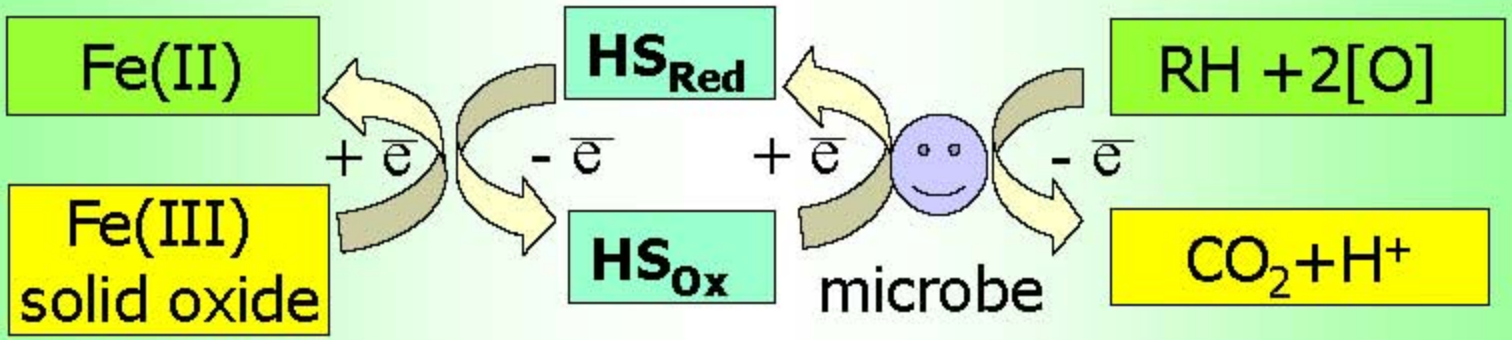
THE PROPOSED STRATEGIES

DESIGN OF FUNCTIONAL MATERIALS

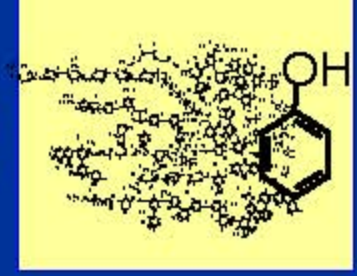
TAILORING REDOX-ACTIVE HUMIC MATERIALS

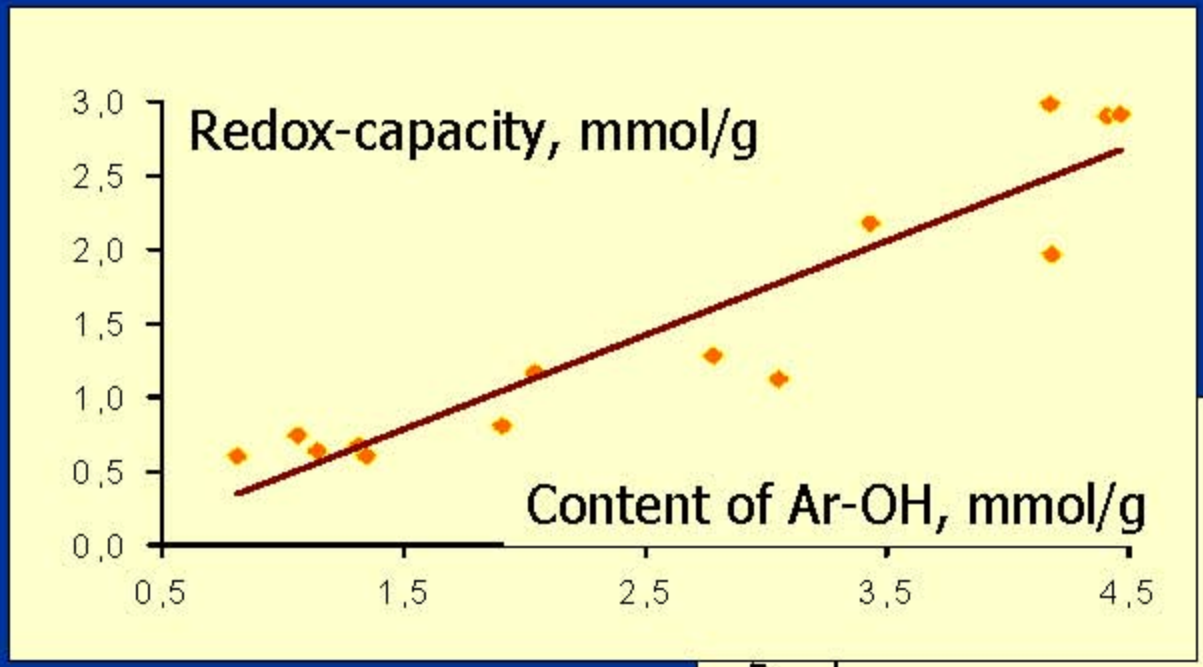


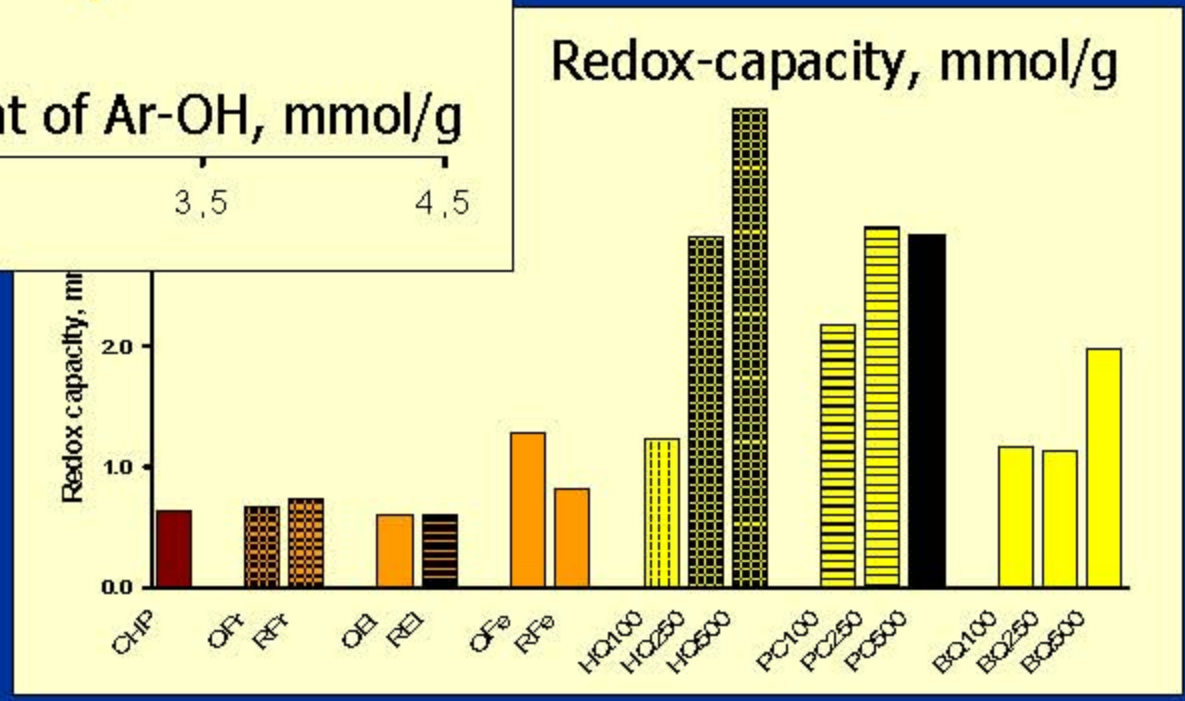
REDOX-MEDIATORS



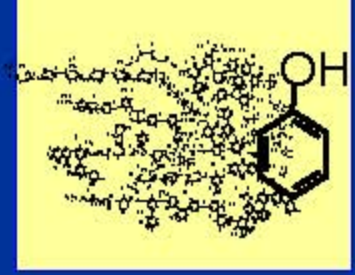
QSAR FOR REDOX PROPERTIES



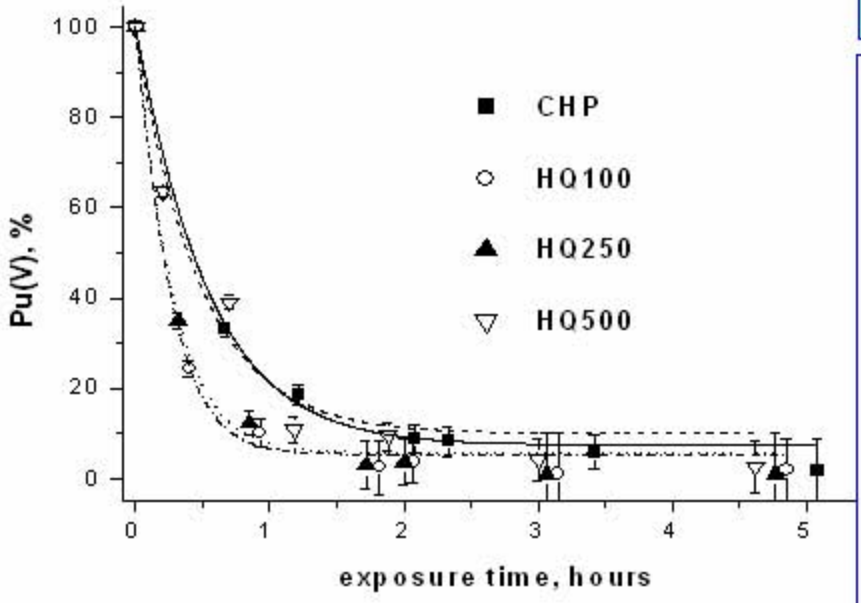




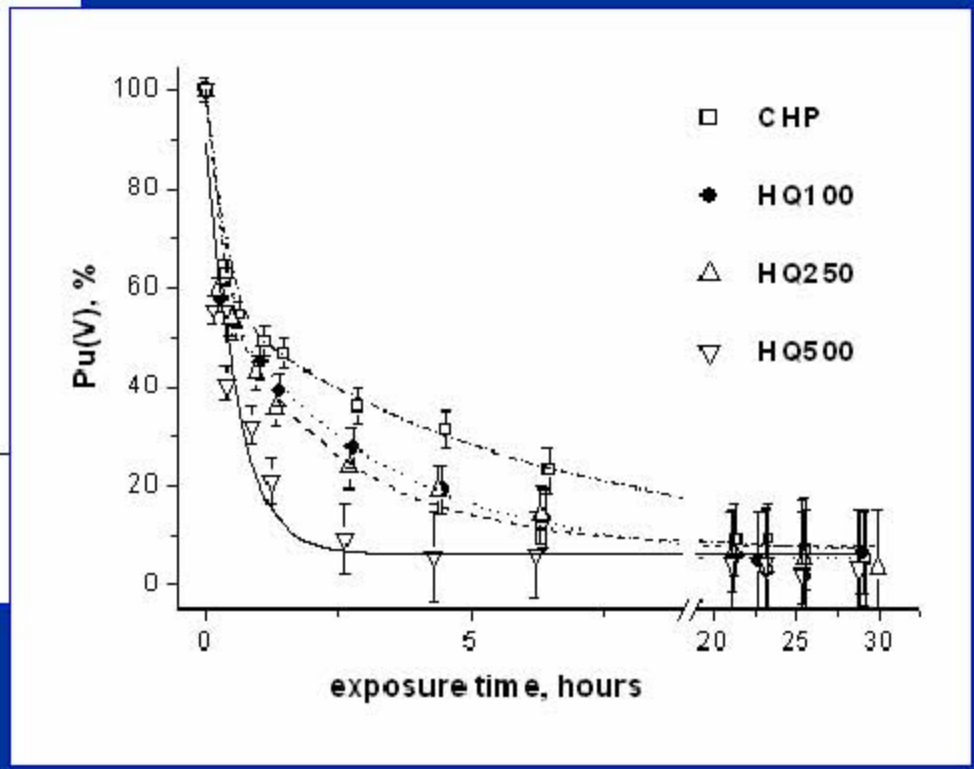
REDUCTION OF Pu(V) BY HQ-ENRICHED HUMICS



ANOXIC CONDITIONS, pH 7.5



OXIC CONDITIONS, pH 4.5



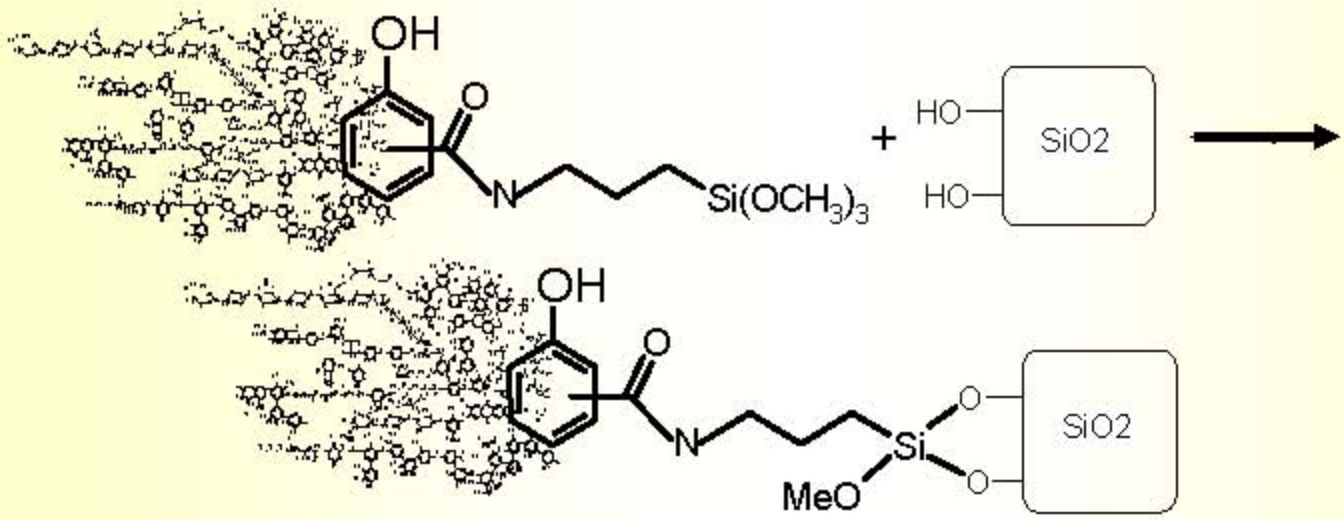
$C_0(Pu) = 2.3 \cdot 10^{-9}$ M,

$C_0(HS) = 10$ mg/L, I ~ 0 M

THE PROPOSED STRATEGIES

DESIGN OF HYBRIDE HUMIC MATERIALS

TAILORING HUMINO-MINERAL COMPOSITES

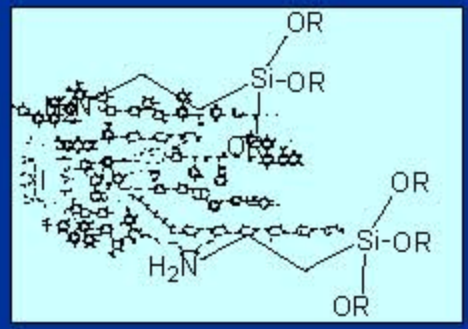


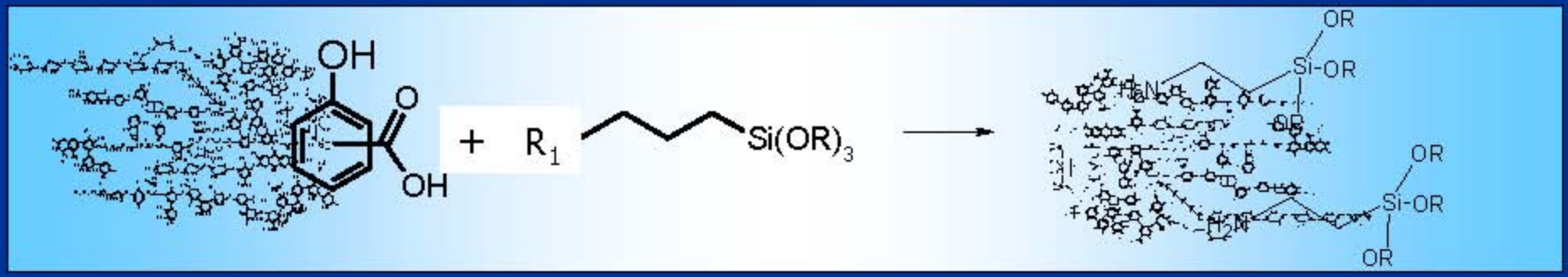
USES IN BIOTECHNOLOGY

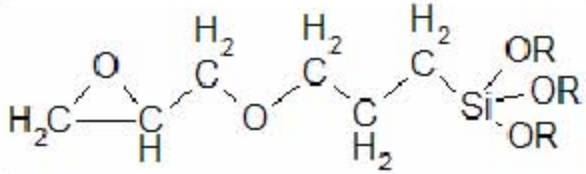
Scavengers - enterosorbents

Biophylic solid supports - biocompatible films

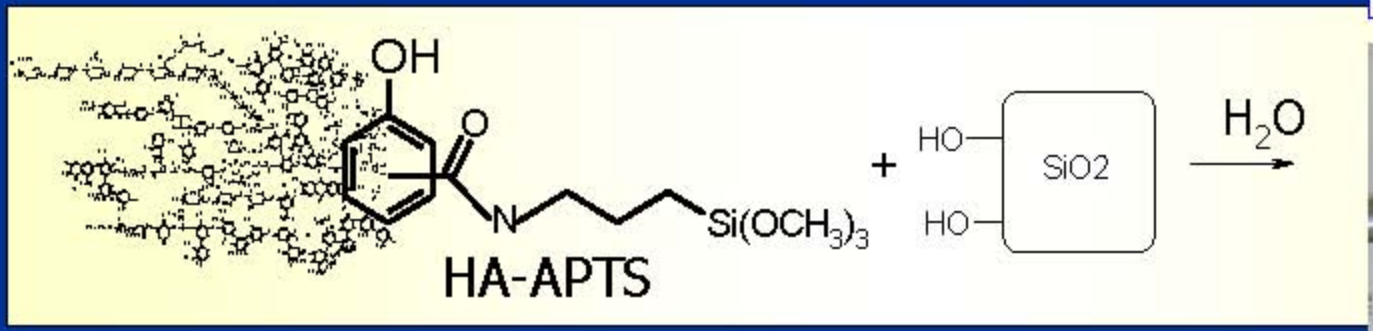
TAILORING HUMIC DERIVATIVES WITH HIGH AFFINITY FOR MINERAL SUPPORT

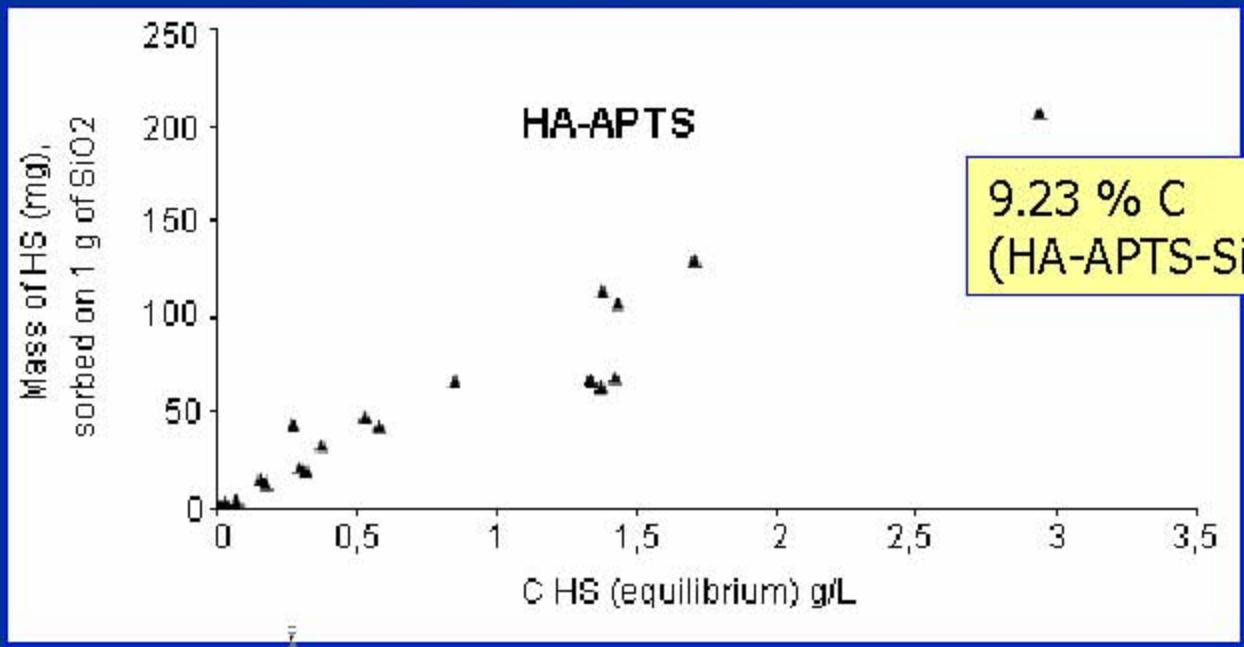




Functionality (R_1)	Organosilane	Structure
Amino	3-aminopropyl-trialkoxysilane (**APTS**)	$H_2N(CH_2)_3Si(OR)_3$
Epoxy	3-glycidoxypropyl-trialkoxysilane (**GPTS**)	
Isocyanate	3-isocyanatopropyl-trialkoxysilane (**IPTS**)	$OCN(CH_2)_3Si(OR)_3$

IMMOBILIZATION OF HUMIC DERIVATIVES ON SiO_2

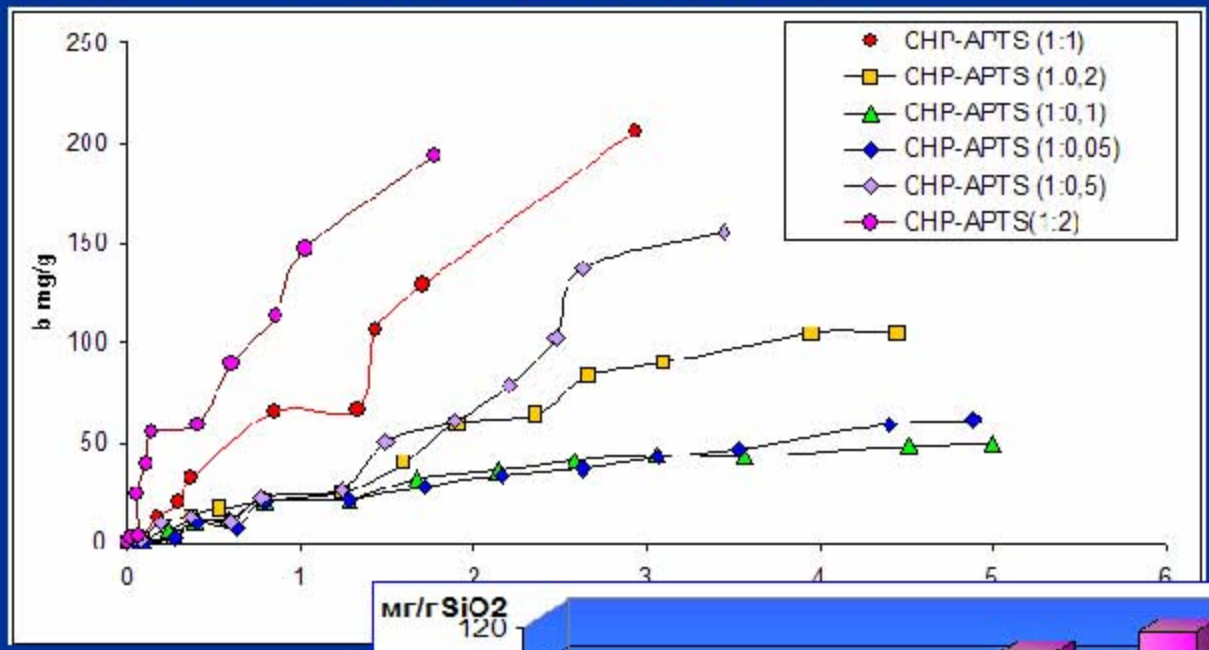




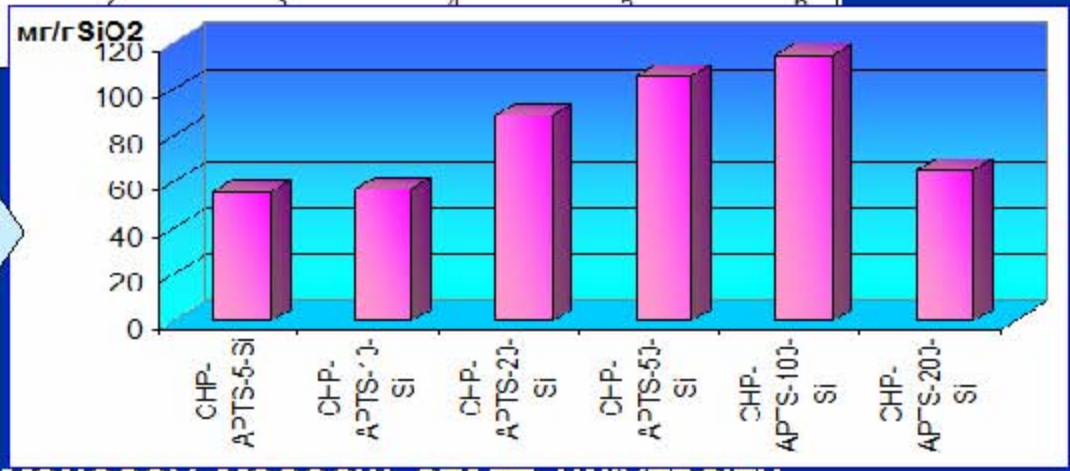
9.23 % C
(HA-APTS-SiO_2)

Parent HS | Modified HS

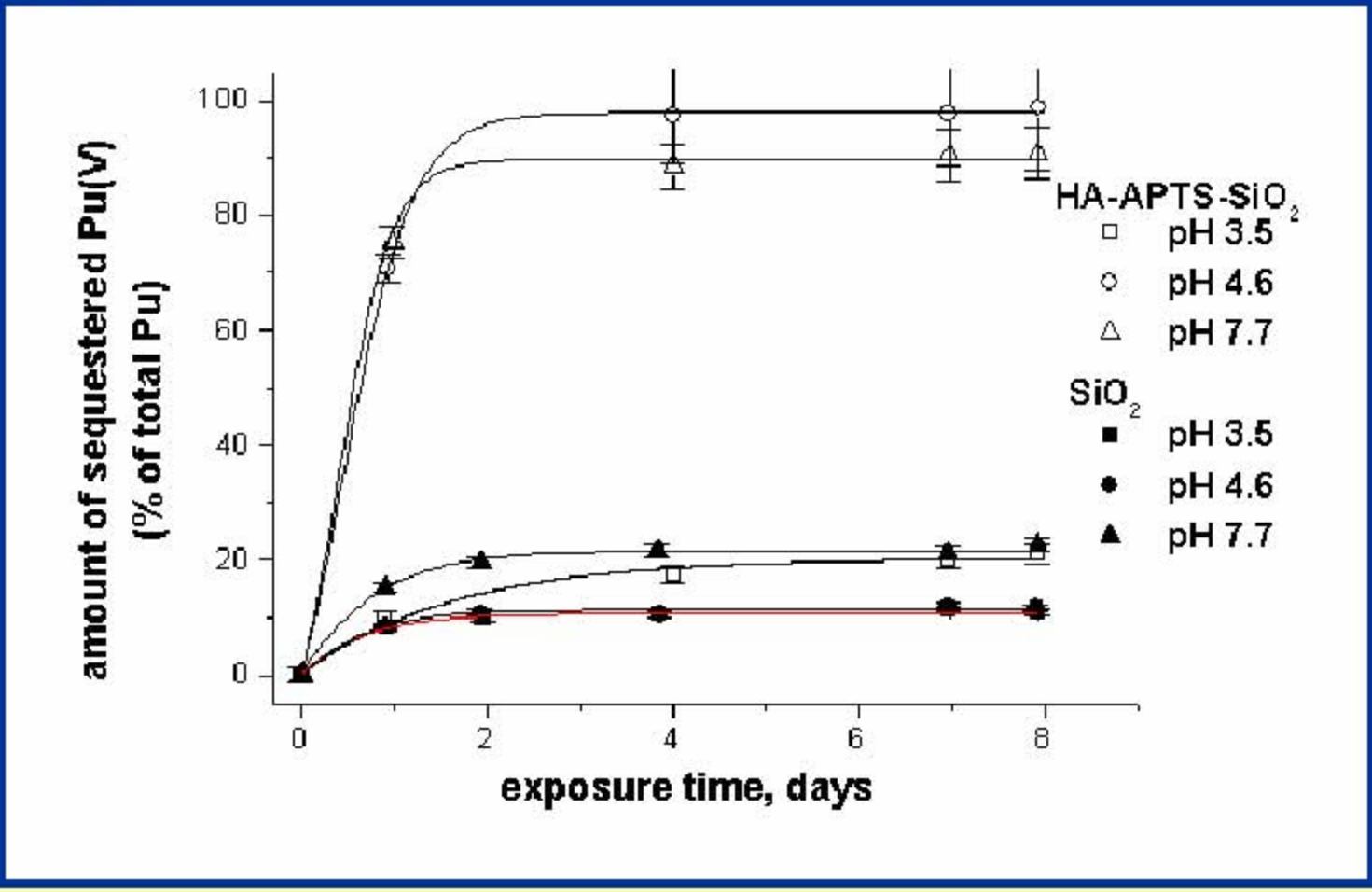
SORPTION OF HUMIC DERIVATIVES WITH DIFFERENT MODIFICATION DEGREE ONTO SILICA GEL



Amount of HS immobilized onto silicagel, mg/g

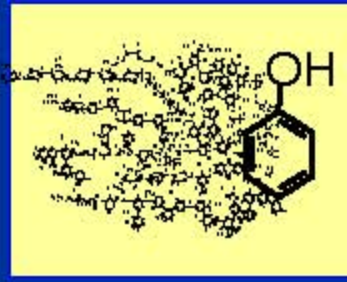


SEQUESTRATION OF Pu(V) FROM SOLUTION

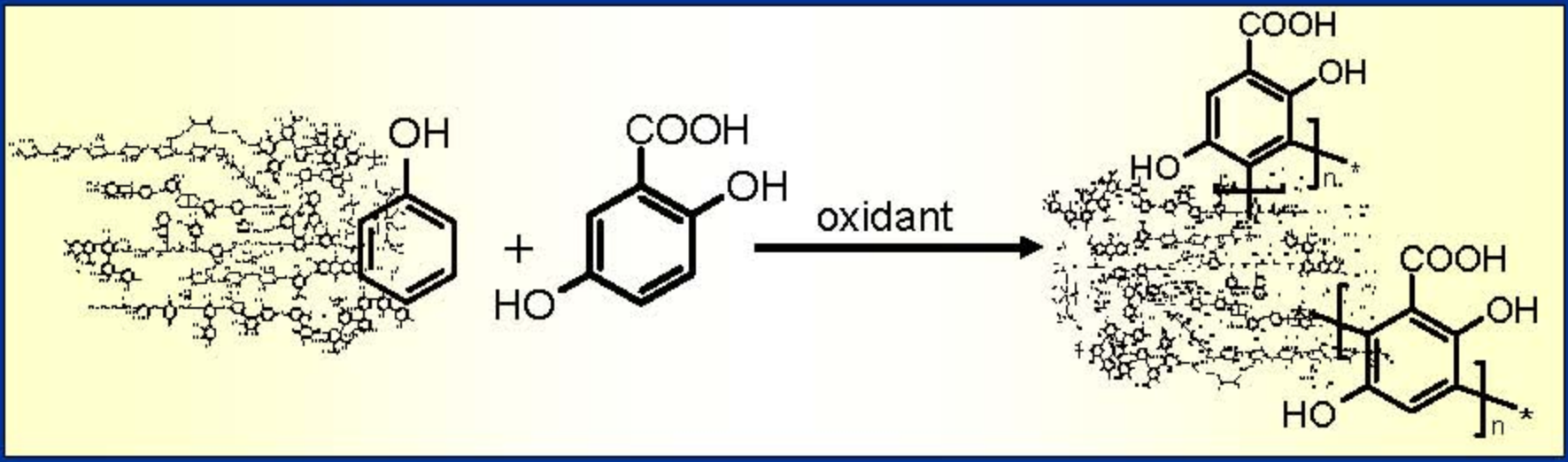


$C_{tot}(Pu)=1.46\cdot10^{-7}$ M, $C(HA\text{-}APTS\text{-}SiO_2)=0.34$ g/L, anoxic conditions

TAILORING HUMICS ENHANCED COMPLEXING PROPERTIES



OXIDATIVE QUINONE CONDENSATION



REACTION CONDITIONS

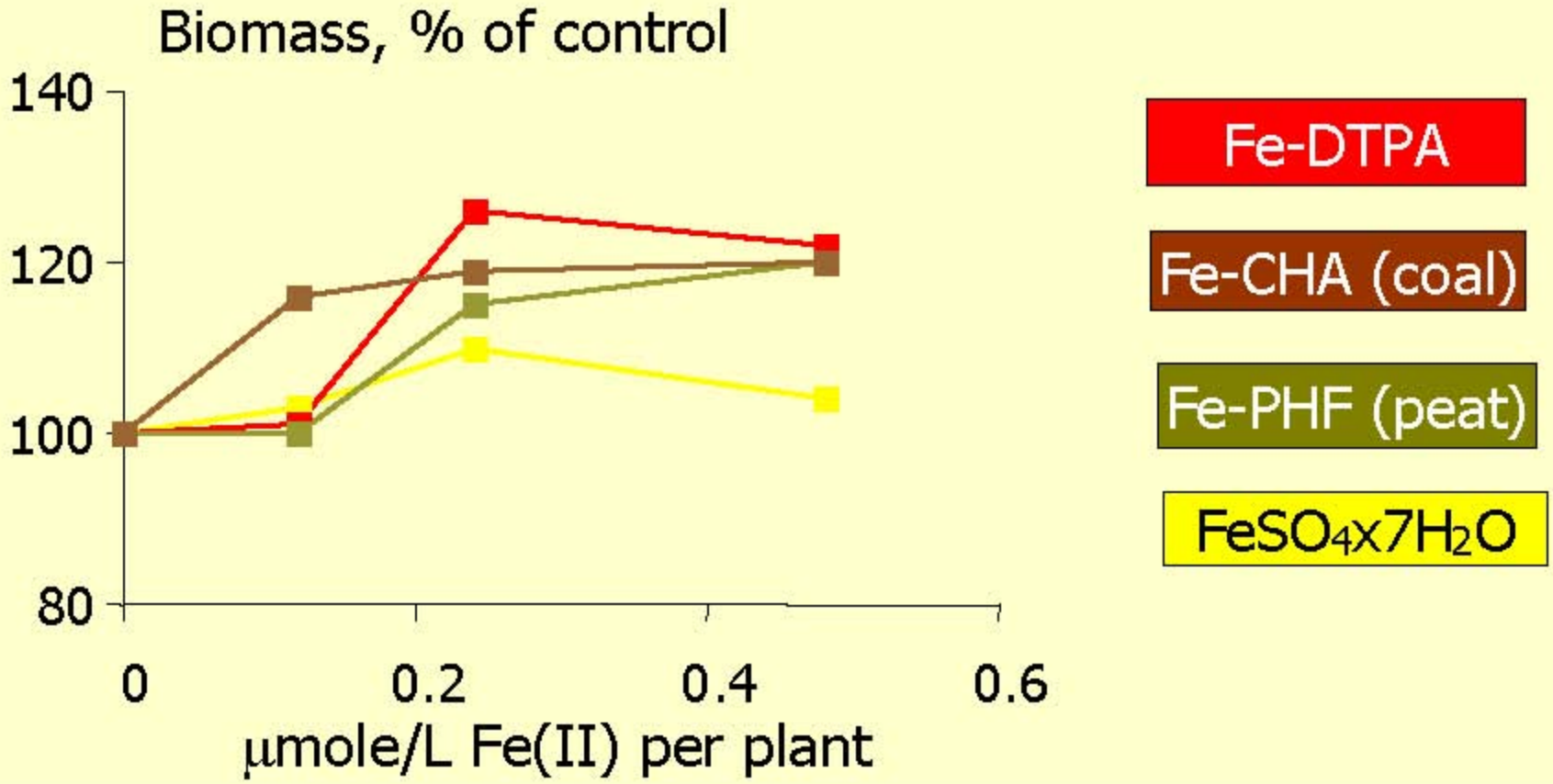
Parent humic material: Leonardite HA (CHP, Powhumus)

Quinonoid component: 2,5-dihydroxybenzoic acid (2,5dhba)

CHP to 2,5 dhba ratio: 1g:250 mg

oxidant: air, pH 9.5; T= 70 °C

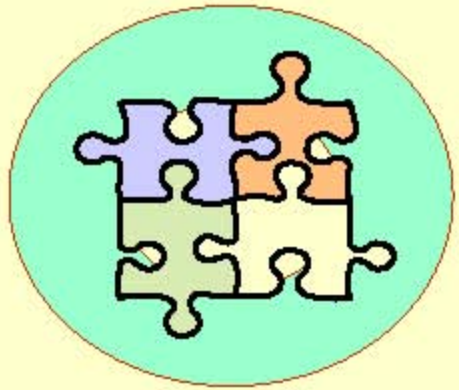
Fe(II)-HS complexes for correction of chlorosis of tomato plants



INNOVATIVE USES IN BIOTECHNOLOGY AND BIOREMEDIATION

BIOTECHNOLOGY, AGRICULTURE AND MEDICINE

- Enzyme carriers
- Biocompatible films
- Biopesticides
- Elicitors
- Micronutrients
- Enterosorbents
- Immunomodulators
- Antioxidants



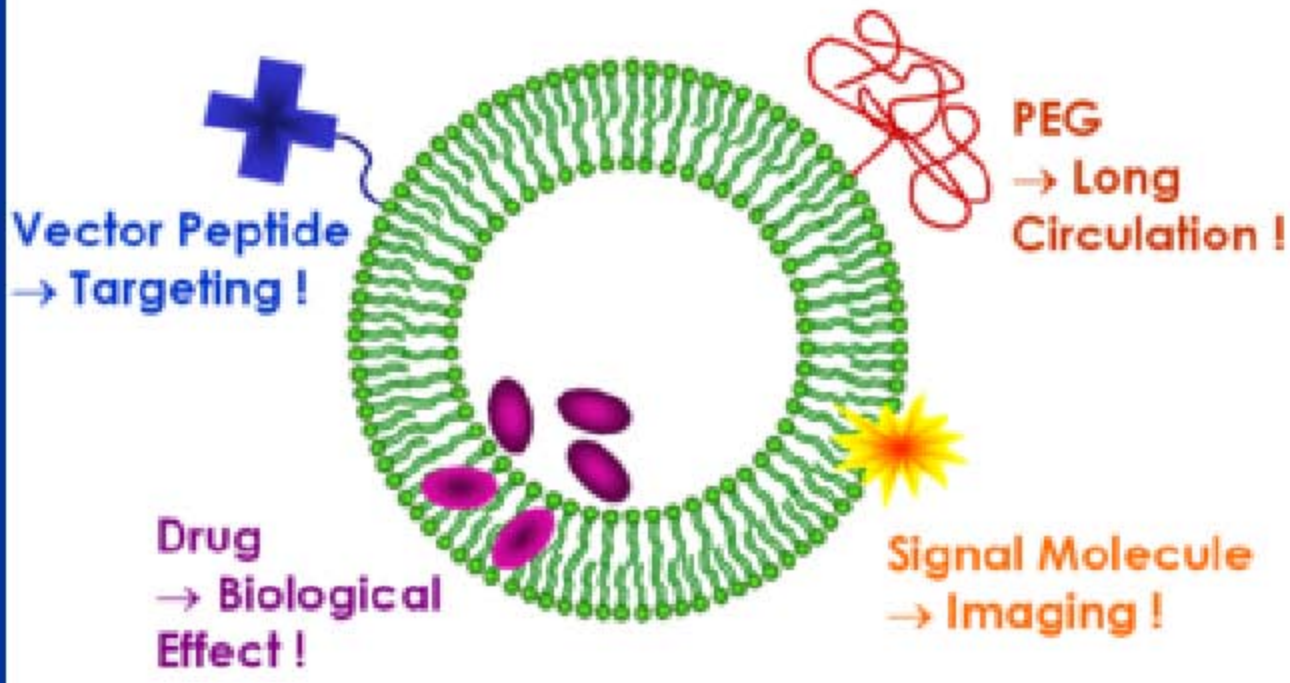
BIOREMEDIATION

- Chelating agents
- Redox mediators
- Detoxifying agents
- Flushing agents
- Sorbents

MULTIFUNCTIONAL THERAPEUTICS: WHAT IS THIS?

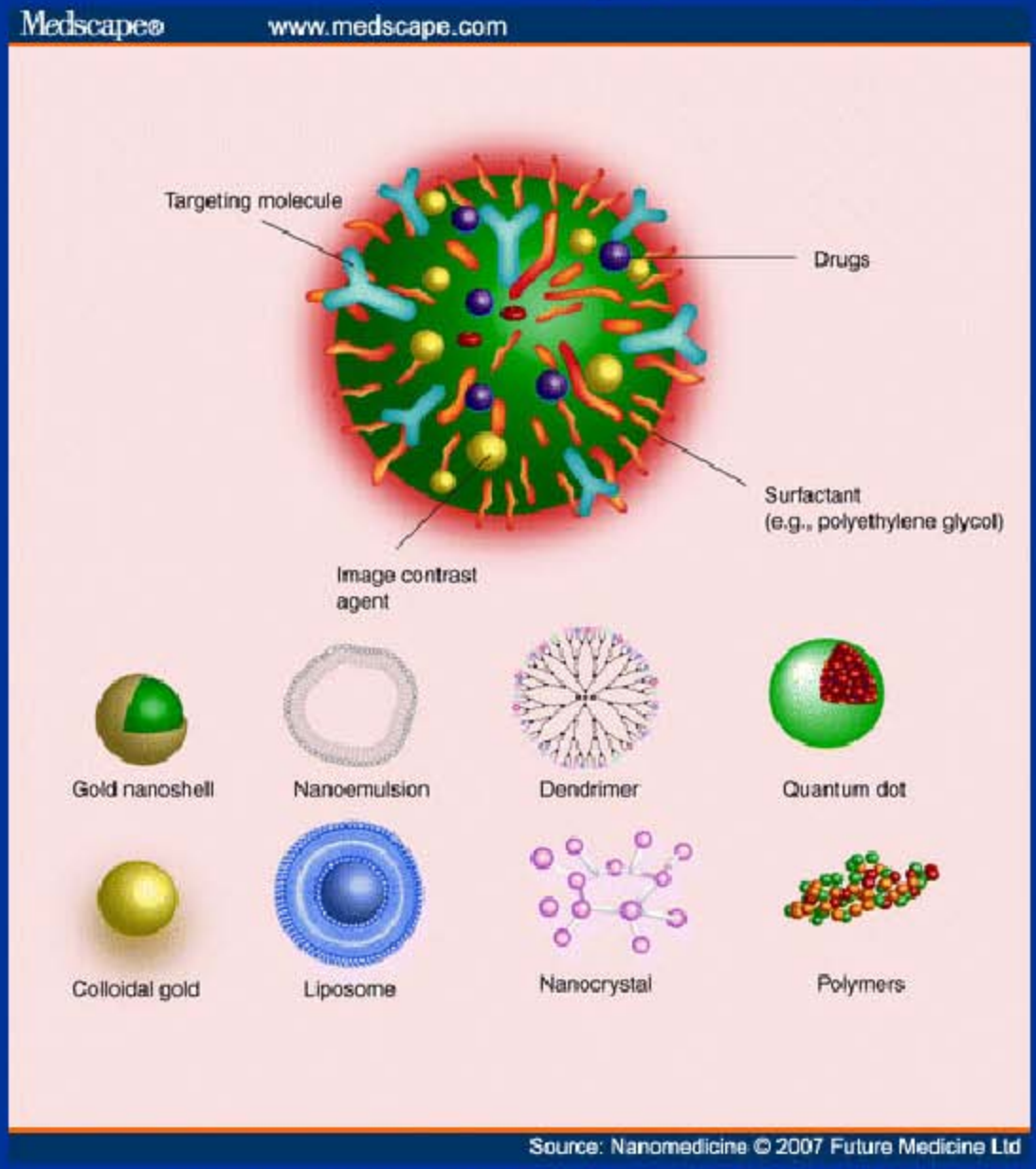
Nanodevices that have a core loaded with drug for biological effect, hydrophilic periphery for long circulation in body fluids, vector peptide for targeting and signal molecule for imaging

EXAMPLE: MULTIFUNCTIONAL MICELLS AND LIPOSOMES

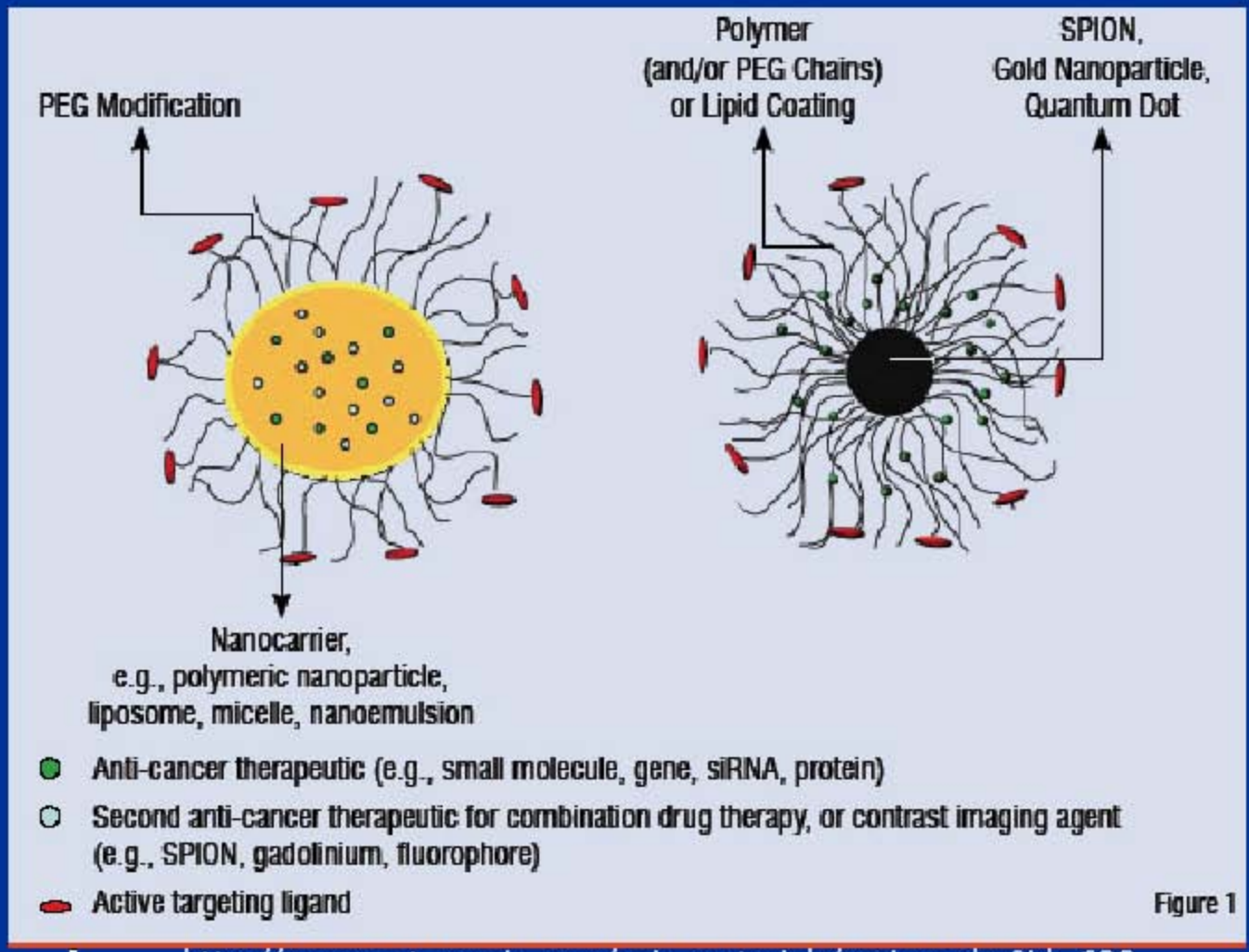


http://www.fmp-berlin.de/projectspeptidelipidinteractio.html

WHAT CAN THEY BE COMPOSED OF?

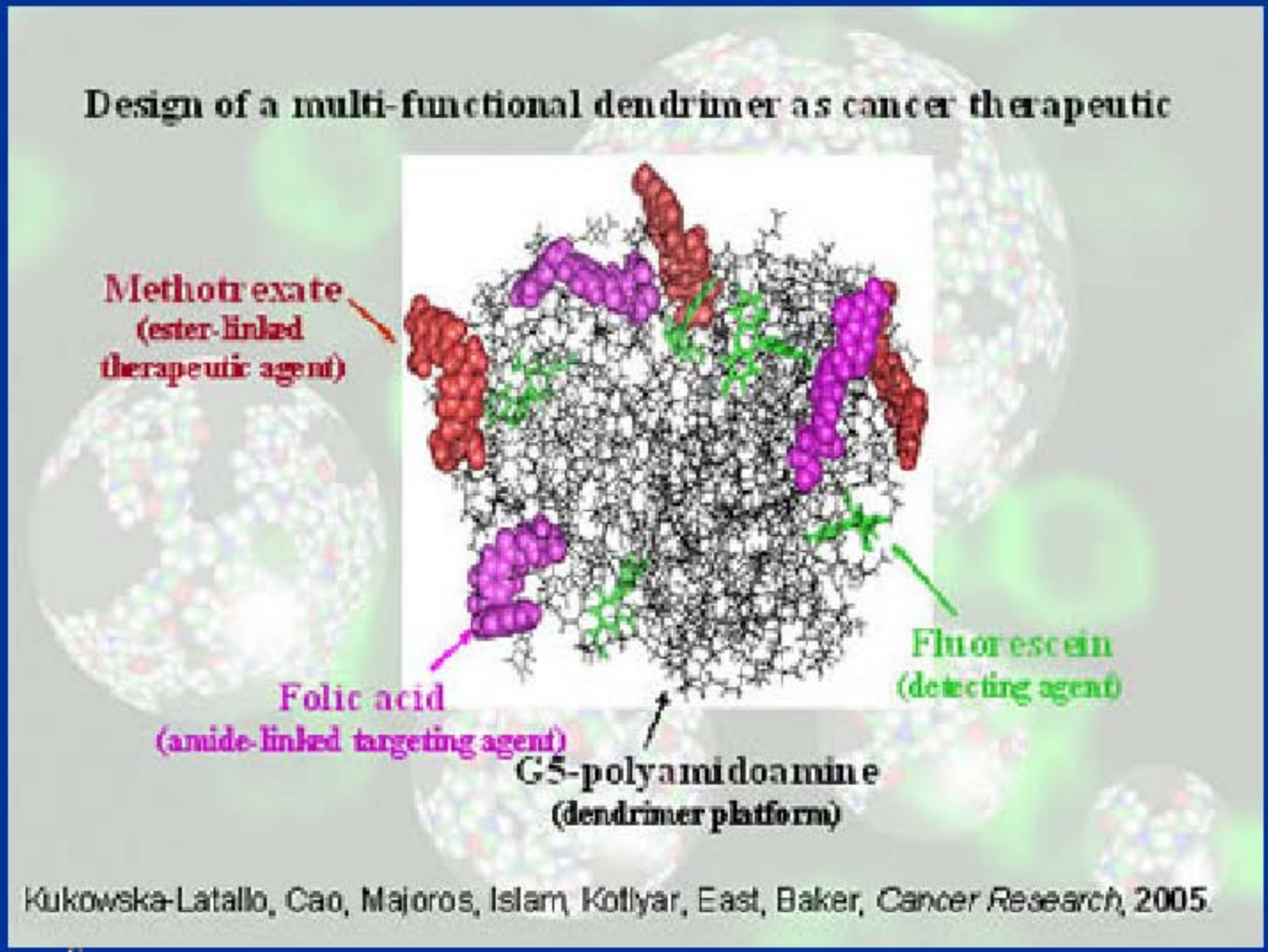


ORGANIC / INORGANIC HYBRIDE THERAPEUTICS

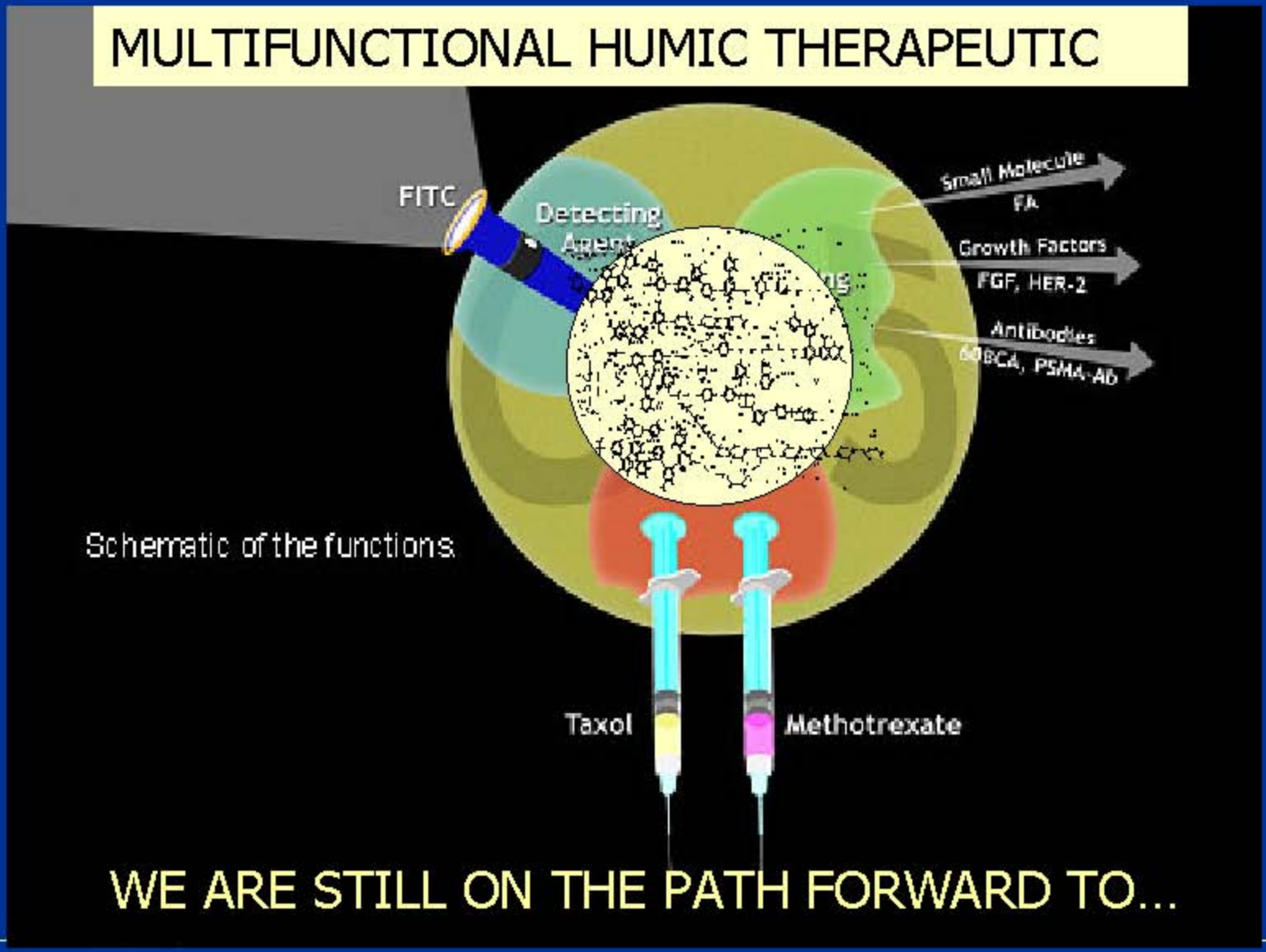


http://www.natureasia.com/asia-materials/review.php?id=629

MULTIFUNCTIONAL THERAPEUTIC FROM DENDRIMERS

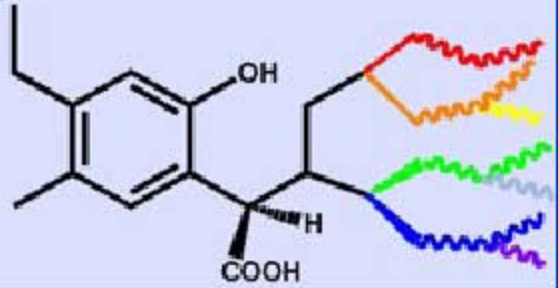


MULTIFUNCTIONAL HUMIC THERAPEUTICS



Acknowledgements
MGUMUS-research group

HiT2010
Conference



THANK YOU VERY MUCH!

СПАСИБО БОЛЬШОЕ!