Nanotechnology applications in food and its possible toxicity



Dr. Alaaeldin Gad

Institute for Semiconductor Technology, Braunschweig University

of Technology, Germany

Inorganic Chemistry Department, National Research Centre,

Cairo, Egypt

HALAL AND TAYYIB PRODUCTS WORKSHOP

25.10.2015

Nanotechnology

□ Nanotechnology is science, engineering, and technology conducted at the nanoscale



Nanotechnology



A Human Hair is about 40 to 150 micrometer

A look back in history

Nanotechnology in the pre-modern era



Lycurgus Cup glass 4th century, Roman Au, Ag Nanoparticles (70 nm)

Source: wikipedia



Medieval stained glass windows

Source: www.nano.gov

A look back in history

		One trillion \$ industry
Moore's L	aw	
"density of tran on an integrate	ed chip" Introduction of <i>"nanotechnology"</i> Norio Taniguchi	<i>Creation:</i> <i>ag Era of</i> <i>onology</i> " Dexler
"There's Plenty of Room	Invention of STM	
Richard P. Feynman First HF transistor	discovery of fullerenes	
1953 1959 19	65 1974 1981 1985 1	986 2015

Nanomaterials

Materials of which a single unit is sized (in at least one dimension) between 1 and 100 nanometers (10^{-9} meter)





nanocrystals

nanotubes, nanowires

nanowalls, nanofilms

Nanomaterials

Materials of which a single unit is sized (in at least one dimension) between 1 and 100 nanometers (10^{-9} meter)



NANO-wonders!

Bulk-Gold

- ✓ Shiny
- ✓ yellow noble metal
- ✓ does not tarnish
- ✓ non-magnetic
- ✓ melts at 1336 K

Nano-Gold

- ✓ appear red
- melting temperature
- ✓ magnetic



Electron microscopy of Au nanoparticles



Tunable absorption properties of Au



Langmuir 2015, 31, 3527-3536

Applications of Nanotechnology

Drug delivery



Electronics



Medical Diagnostics



Catalysis



Internet of things



Energy/Environment



Nanotechnology in Food



Nanotechnology in Food

Benefits vs. Risks

Nanomaterials do not behave like their bulk counterparts

□ Higher surface to Volume ratio

- more atoms exposed
- increased molecular activity

Are Surface Area, Surface Charge/reactivity/functional groups, Morphology, Aggregation behavior now Key Parameters ?

Small size increases biological access, absorption and distribution

Blood brain barrier, placental barrier, etc.

Nanotoxicology

- Nanotoxicology Science of engineered nanodevices and nanostructures that deals with their effects in living organisms
- Potential exposure routes

Inhalation

Engineered nanoparticles

- carbon-based materials
- Inorganic nanoparticles
- metals
- quantum dots
- nanosized polymers
- Composites

Toxicity of Metal Oxide Nanoparticles in Escherichia coli

significant growth inhibitory effects due to membrane damage and oxidative stress responses

Inhibition of E. coli growth by MOx nanoparticles

What Matters?

The dynamic transformations nanoparticles undergo in the body or the environment

□ Solubility of NPs

release of metal ions may induce cytotoxicity

- Surface adsorption of NPs may adsorb proteins and soluble salts and induce cytotoxicity
- □ Increase of surface

area enhances surface activity e.g. ROS production

Surface Modification Matters !

citrate-Ag NPs were more toxic than PVP-Ag NPs

Size-dependent toxicity silver nanoparticles

Cytotoxicity of naked 4 nm ZnO-NP

Cytotoxicity of modified ZnO-NP after 24h

Morphology Matters!

Inhibition of Toxicity by Surface Encapsulation

ACS Appl. Mater. Interfaces 2014, 6, 19327-19335

Toxicity : Still Debating

clear correlation is needed between the biological impact of nanomaterials and their properties such as size, surface structure, crystalline phase, chemical composition, presence of metal trace impurities

□ Every condition leads to a different biological response

Thanks for your kind attention

email:

a.gad@tu-braunschweig.de

agadnrc@gmail.com