Kingdom of Saudi Arabia, Jeddah
King Abdulaziz University
Faculty of Science
Chemistry Department

Selective Adsorption of Gold Ions from Complex System using Oxidized Multi-Walled Carbon Nanotubes

Huda A. Shaheen*, Hadi M. Marwani, Ezzat M. Soliman

Nanotechnology



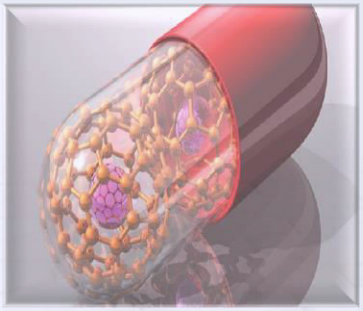
Water treatment and filtration



Energy applications and energy storage



Oil and gas petroleum



Pharmaceuticals and healthcare



Electronics



Biotechnology



Robotics

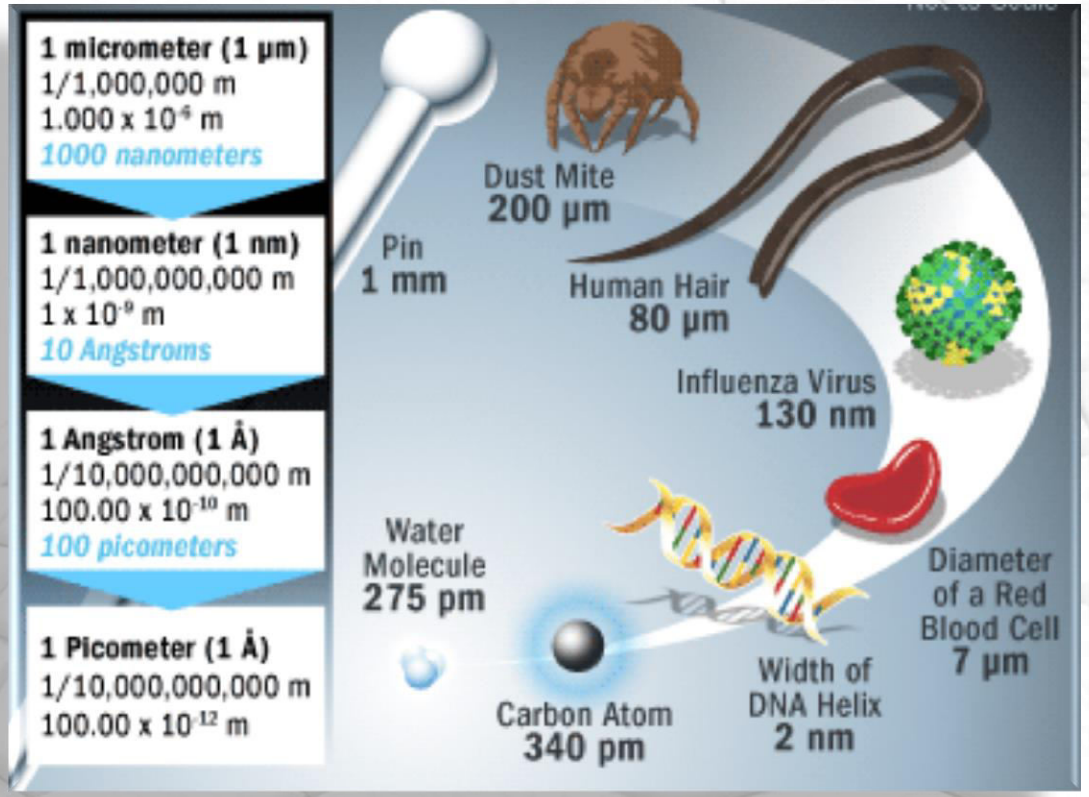


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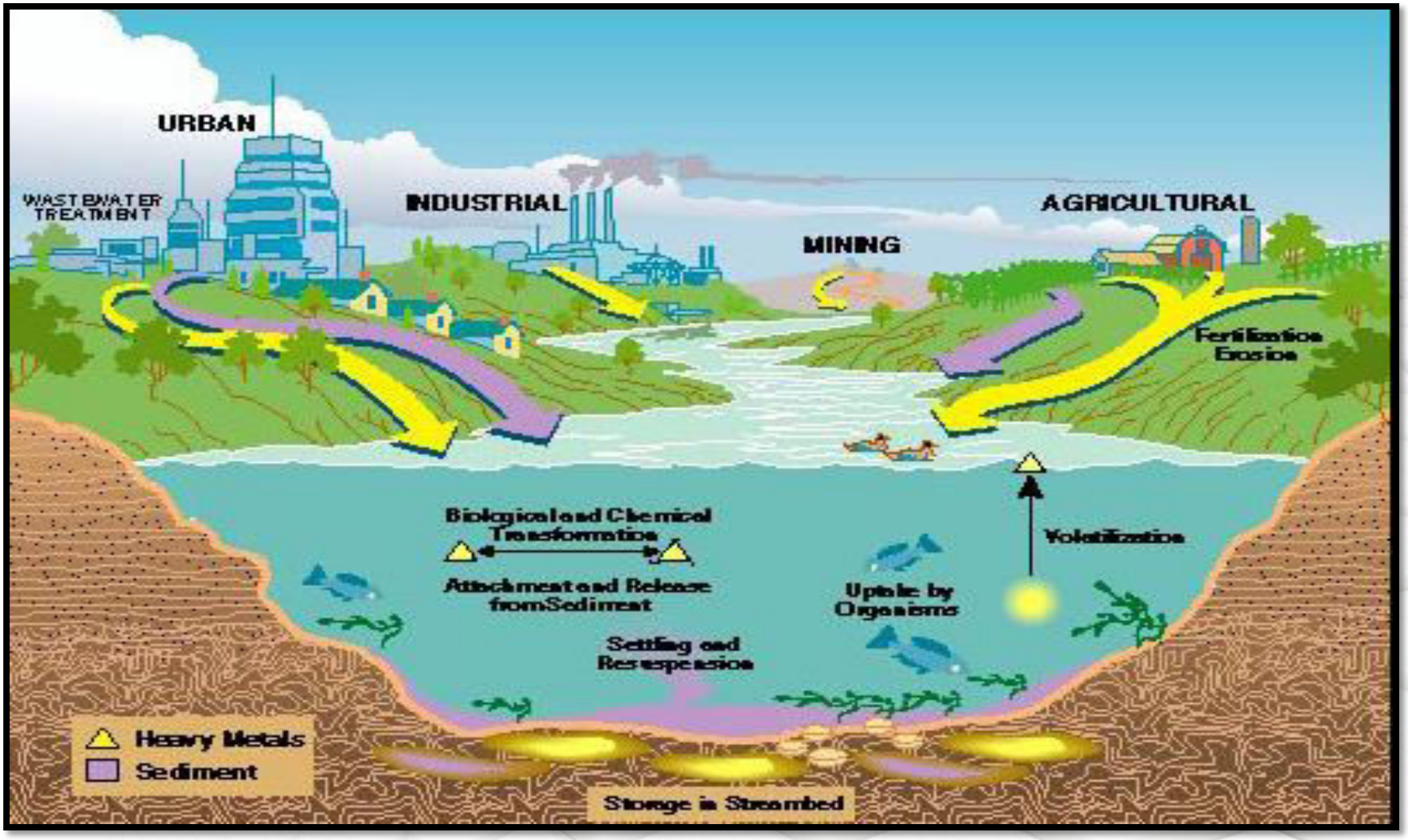
Nanotechnology

Nanotechnology is already making today's products in order to have unique properties:

- Lighter
- Stronger
- Faster
- Smaller
- More durable



Nanotechnology



Nanotechnology



Nanotechnology



Solid phase extraction (SPE)



- Liquid-Liquid extraction
- Chemical precipitation
- Ion-exchange
- Electron deposition

Solid Phase Extractors

Carbon nanotubes (CNTs)





Fly ash



Zeolite



Manganese oxides



Resins



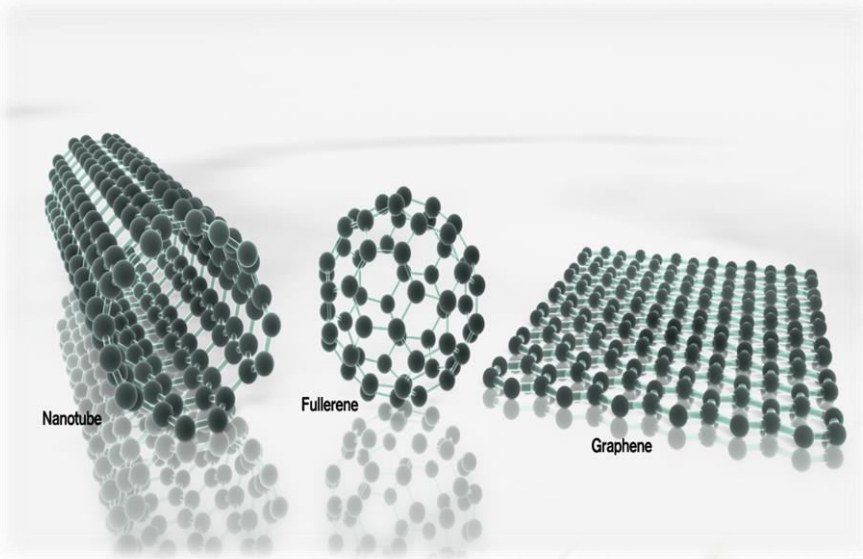
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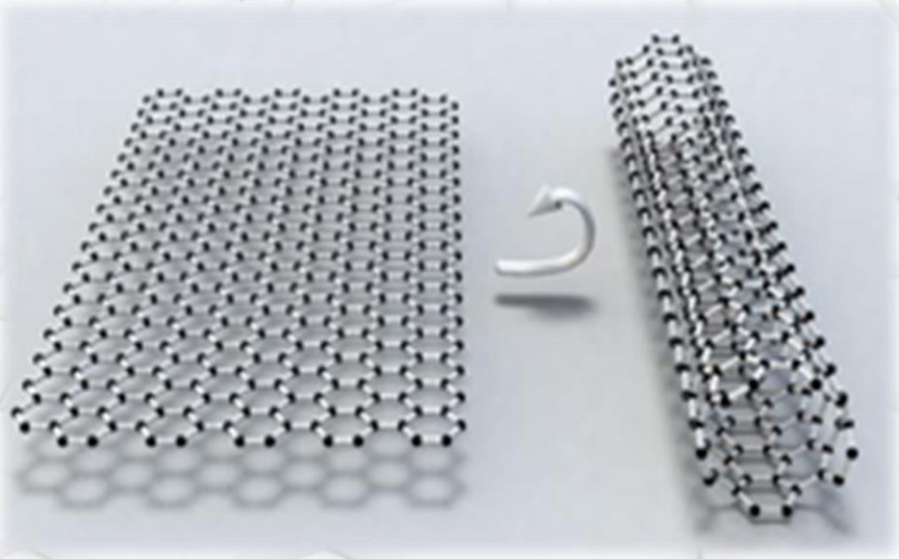


Activated carbon

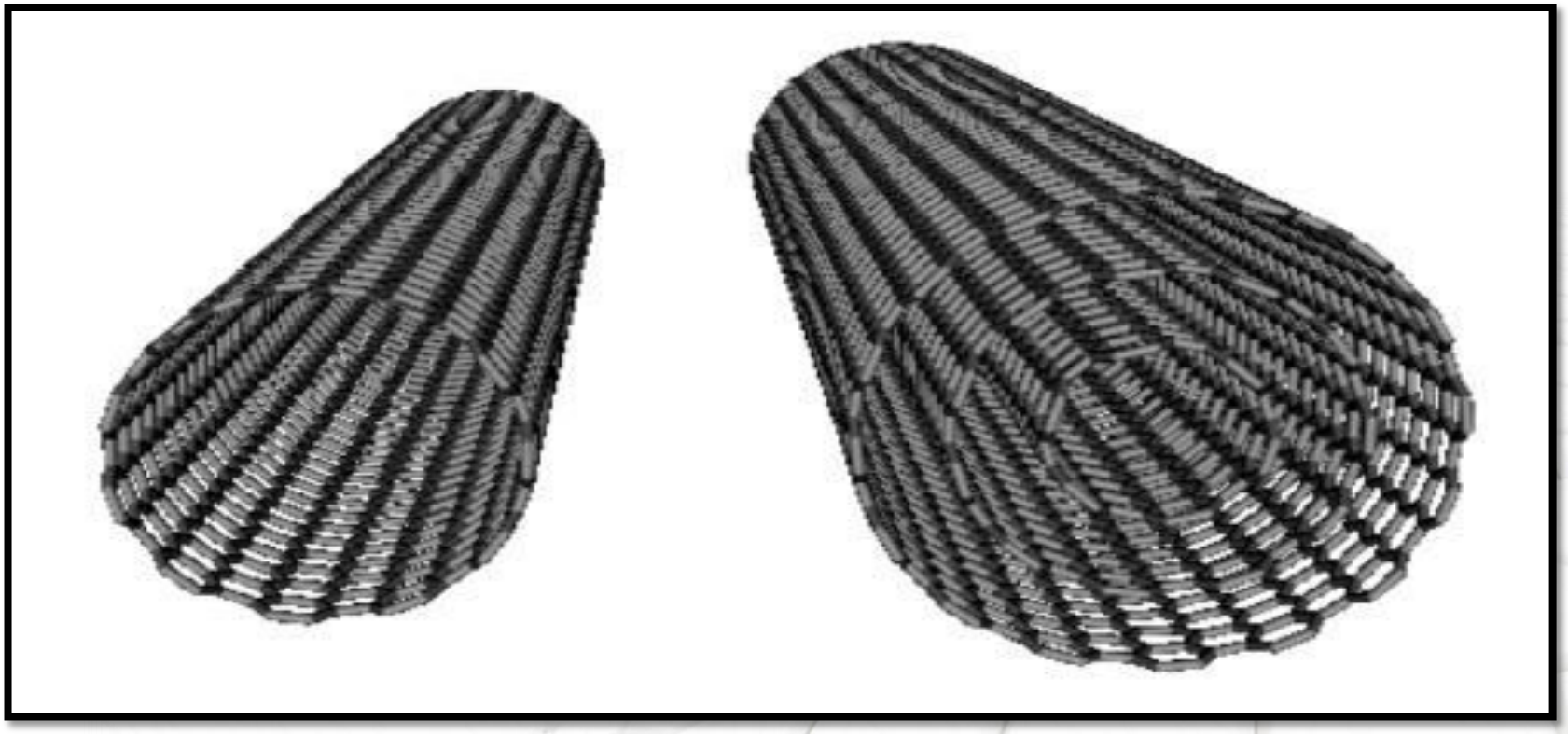
Carbon Nanotubes

Carbon nanotubes are fullerene-related structures in molecular-scale tubes of graphitic carbon.





Types of Carbon Nanotubes



SWCNTs **MWCNTs**

SWCNTs: Single walled carbon nanotubes, MWCNTs: Multi walled carbon nanotubes

Properties of Carbon Nanotubes



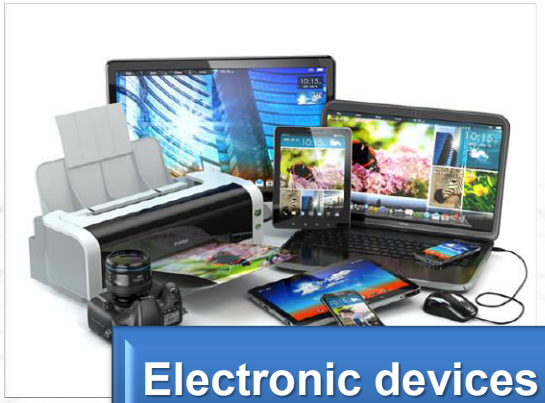
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Electrochemical detectors



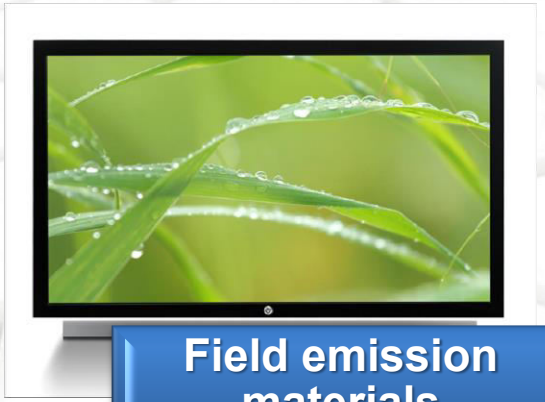
Electronic devices



Reinforced materials



Hydrogen storage



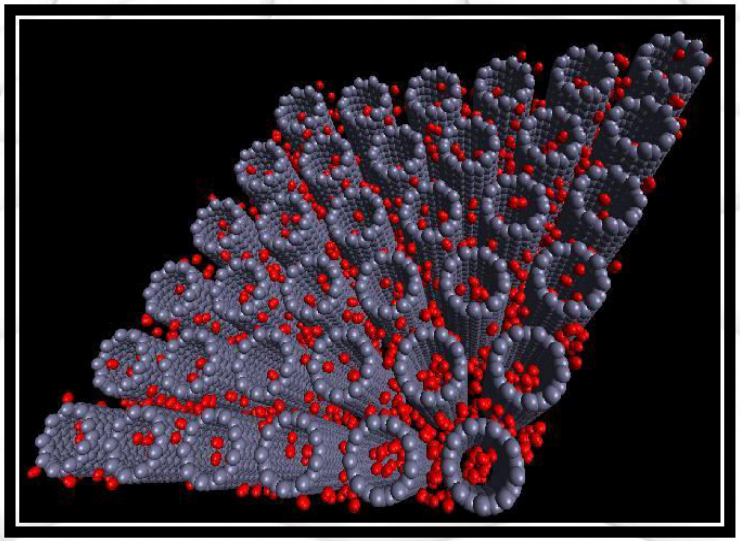
Field emission materials

Applications of Carbon Nanotubes

Due to:

- ✓ The highly porous and hollow structure of CNTs
- ✓ Large specific surface area
- ✓ Light mass density
- ✓ Strong interaction between CNTs and pollutant molecules





The applications of CNTs for the removal of hazardous pollutants have been extensively studied.

Functionalization of Carbon Nanotubes

Using organic chelating agents

Such as ligands

Using oxidizing agents

H_2SO_4, H_2O_2, O_3, HNO_3, $KMnO_4$

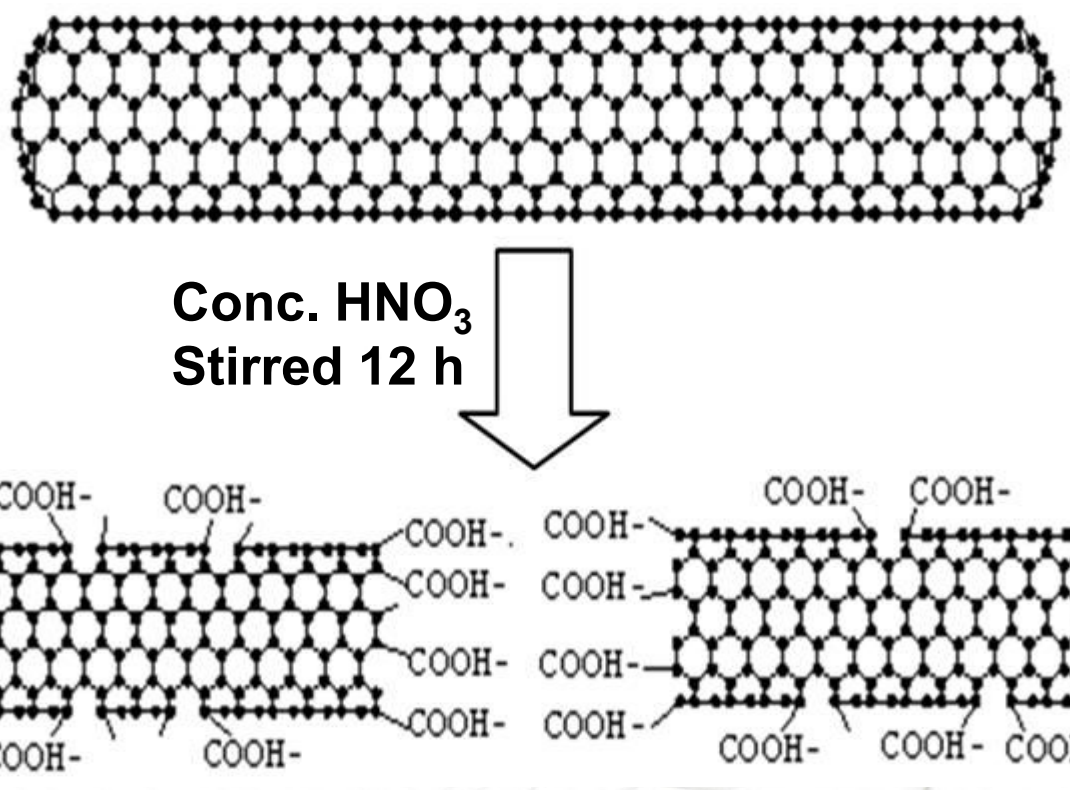
Non-covalent functionalization

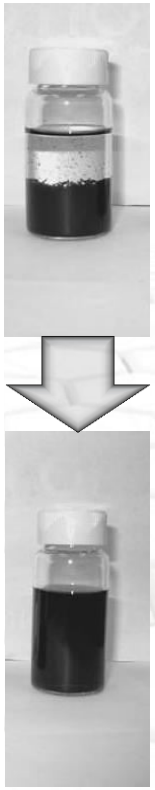
Adsorption forces, such as Vander Waals force, hydrogen bonds, electrostatic force

Covalent functionalization

A covalent linkage between functional entities and the carbon skeleton of nanotubes

Oxidation of the MWCNTs





For surface characterization of MWCNTs and *O*-MWCNTs, FT-IR measurements were performed, and scanning electron microscope (SEM) measurements were acquired

Experimental Studies

Adding certain amount of metal ion stock solutions

↓

Adding 10 mL buffer, completing to 25 mL with DDW

↓

Transferred to 50 mL g.f. containing 10 mg *O*-MWCNTs

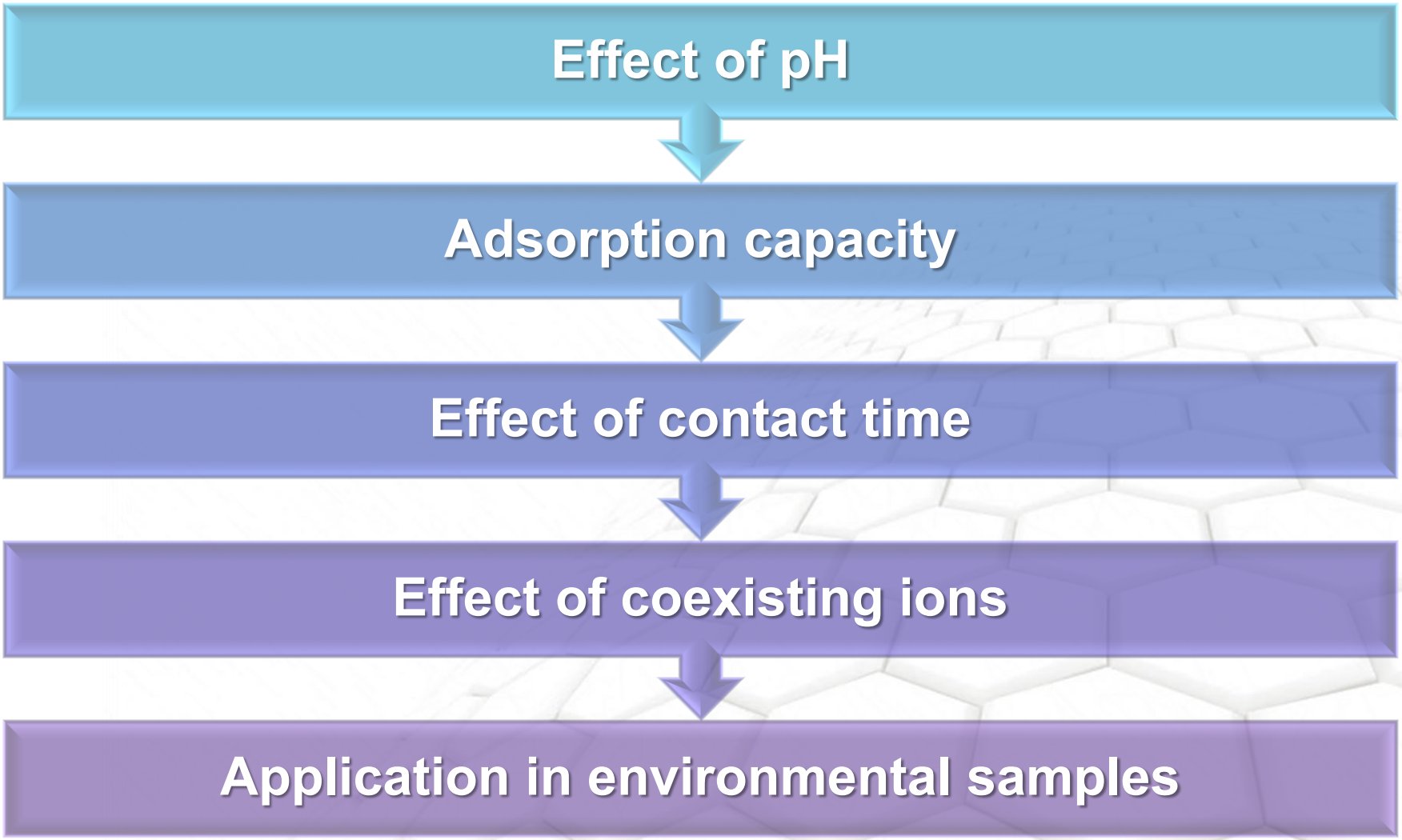
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The mixtures were mechanically shaken for 1 h

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All mixtures were filtrated and determined by ICP-OES

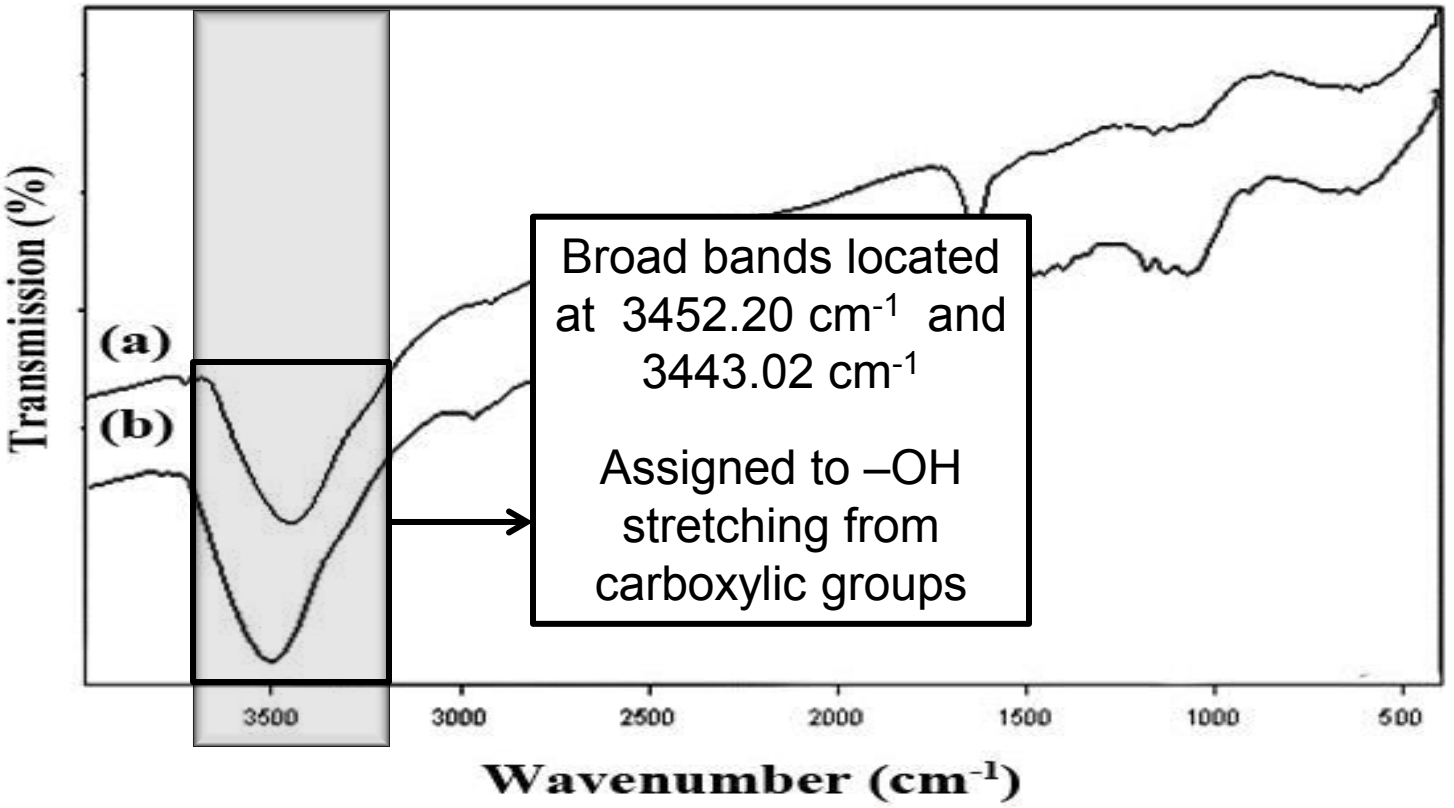
Batch Method Parameters



Results and Discussion

Characterization of *O*-MWCNTs

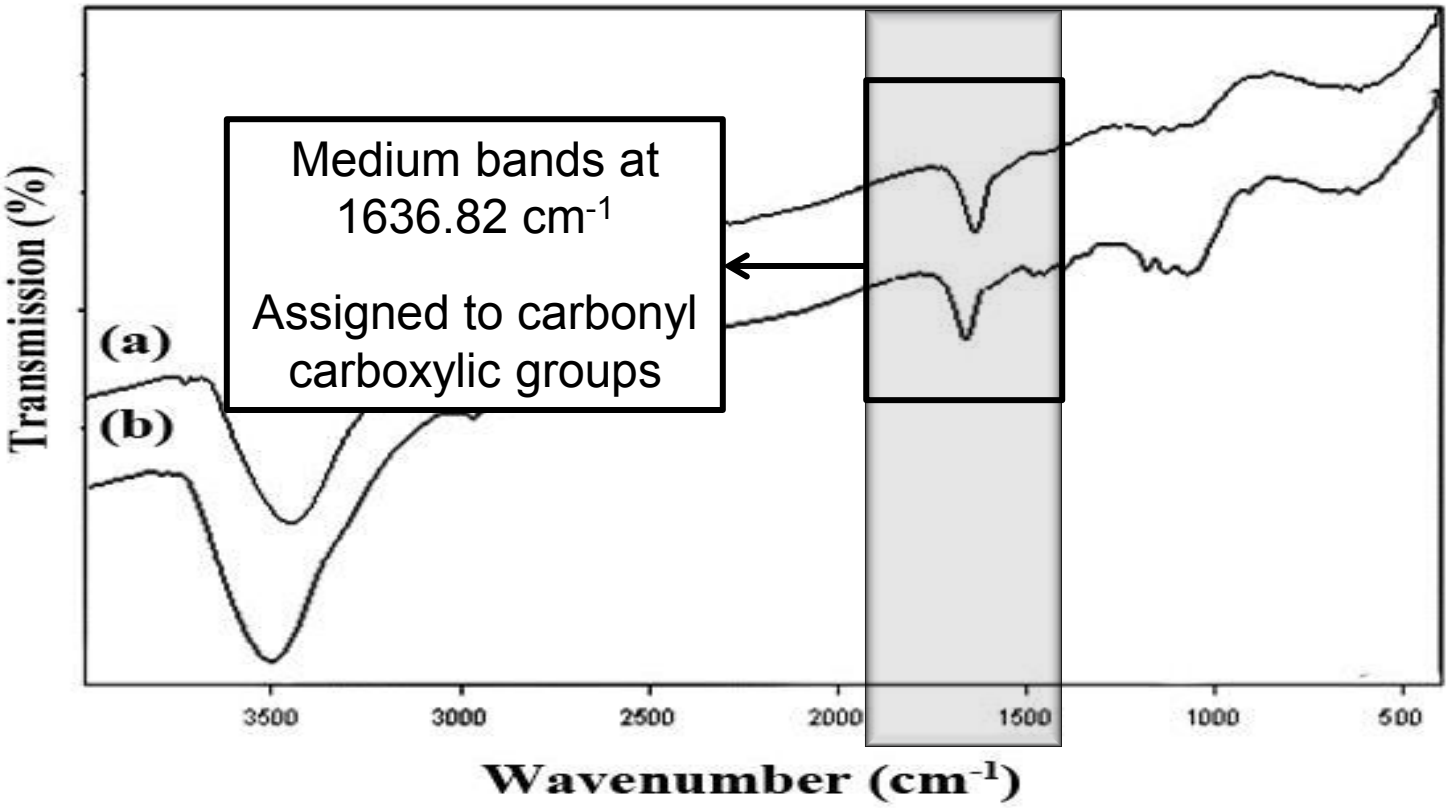
FT-IR



FT-IR spectra of (a) pristine MWCNTs and (b) *O*-MWCNTs.

Characterization of *O*-MWCNTs

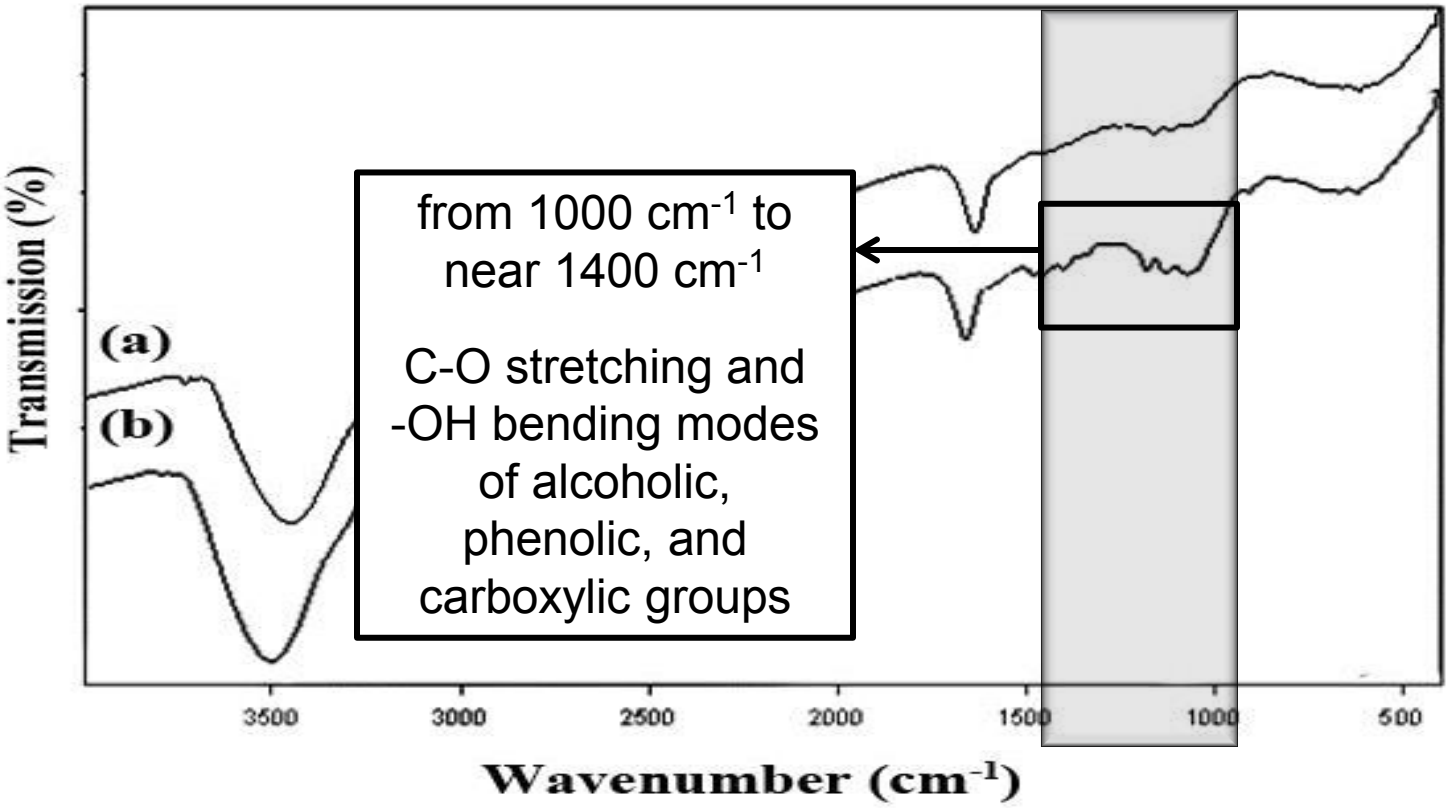
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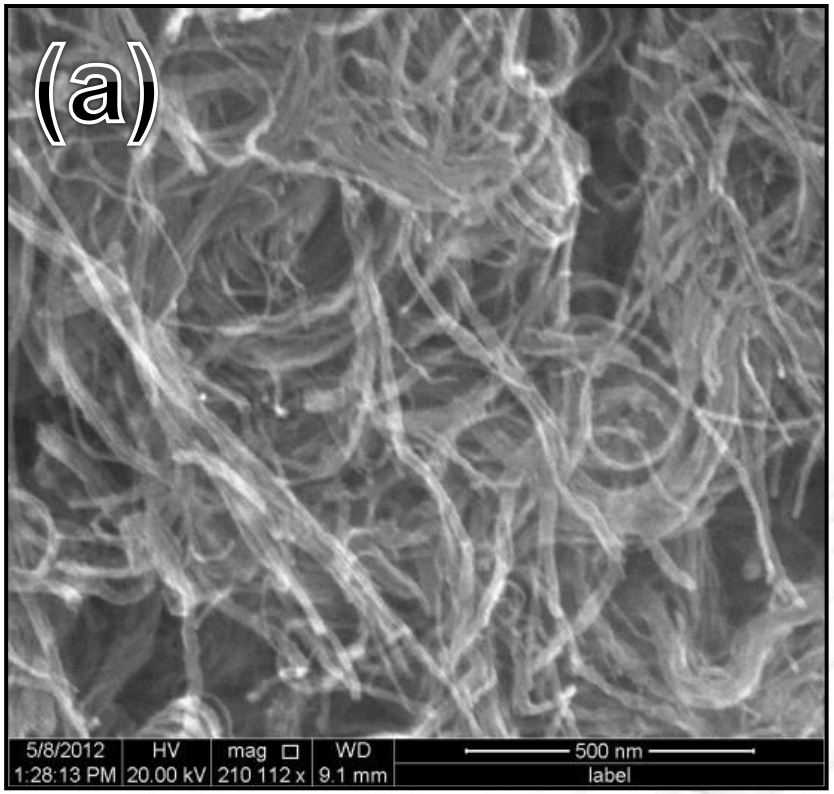
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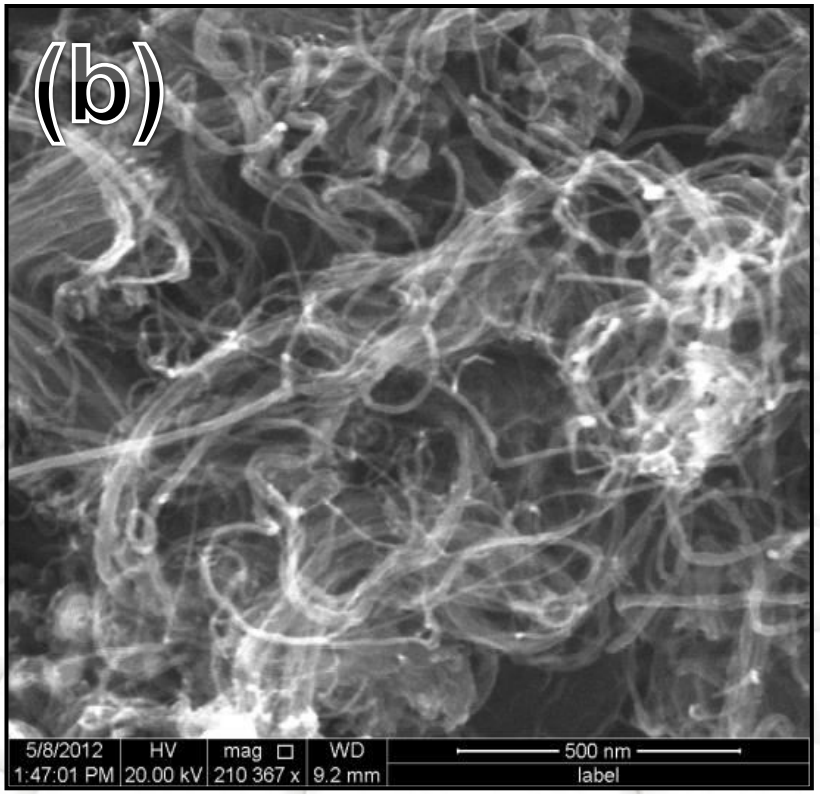


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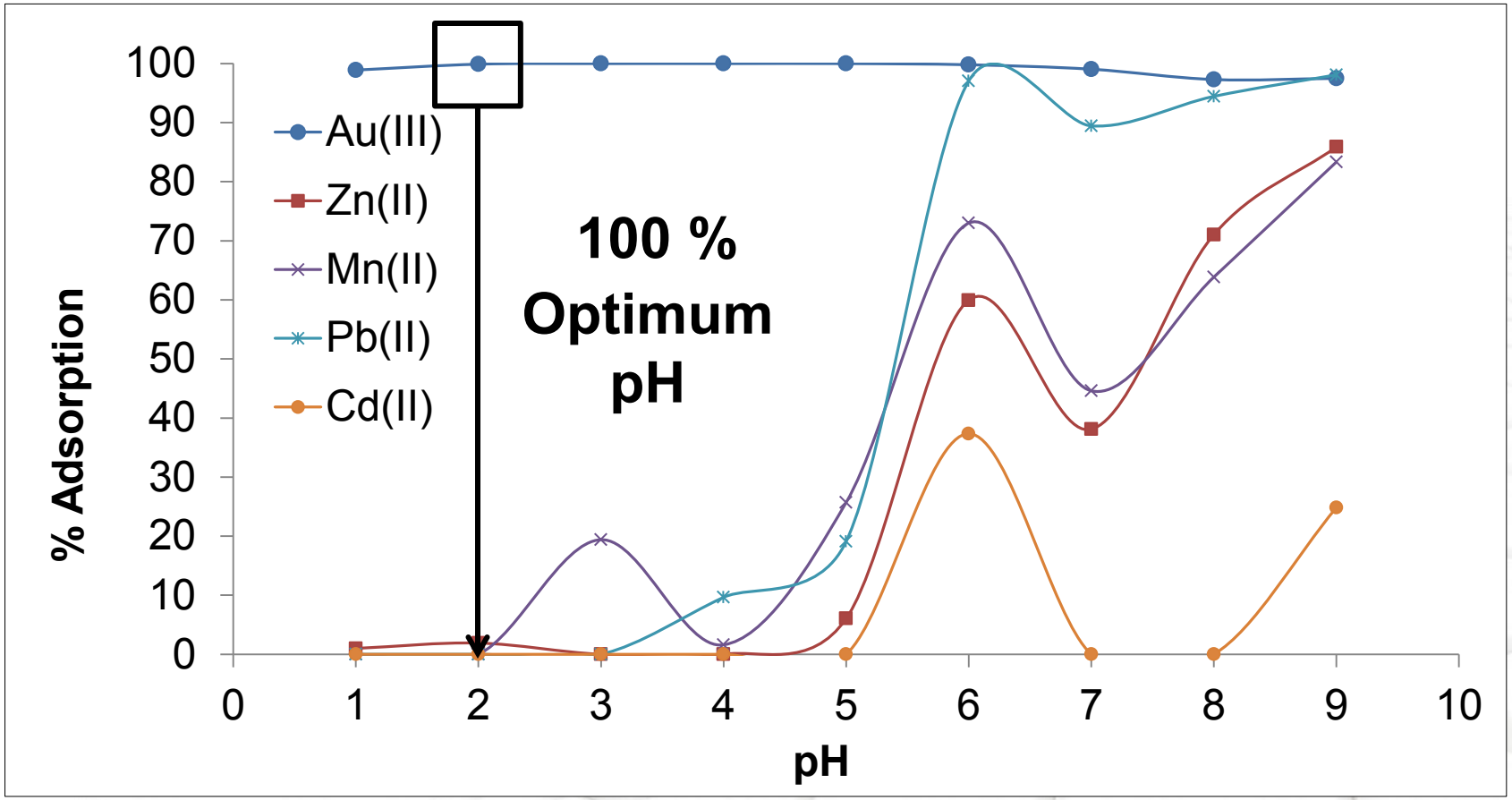
SEM





SEM images for (a) pristine MWCNTs and (b) *O*-MWCNTs.

Effect of pH

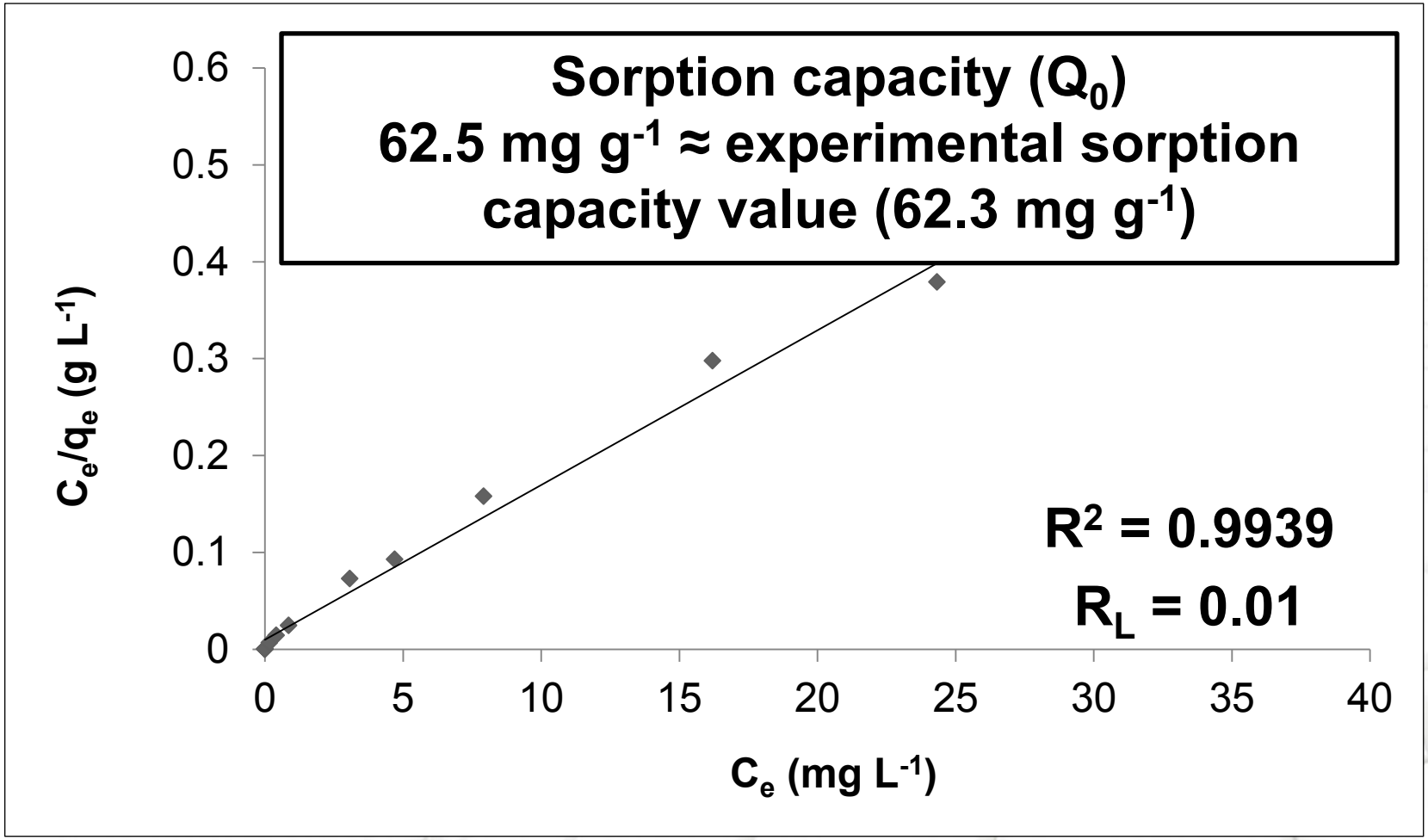


Effect of pH on the adsorption of 2 mg L^{-1} Au(III), Zn(II), Mn(II), Pb(II) and Cd(II) on 10 mg *O*-MWCNTs phase at 25°C.

Adsorption Capacity

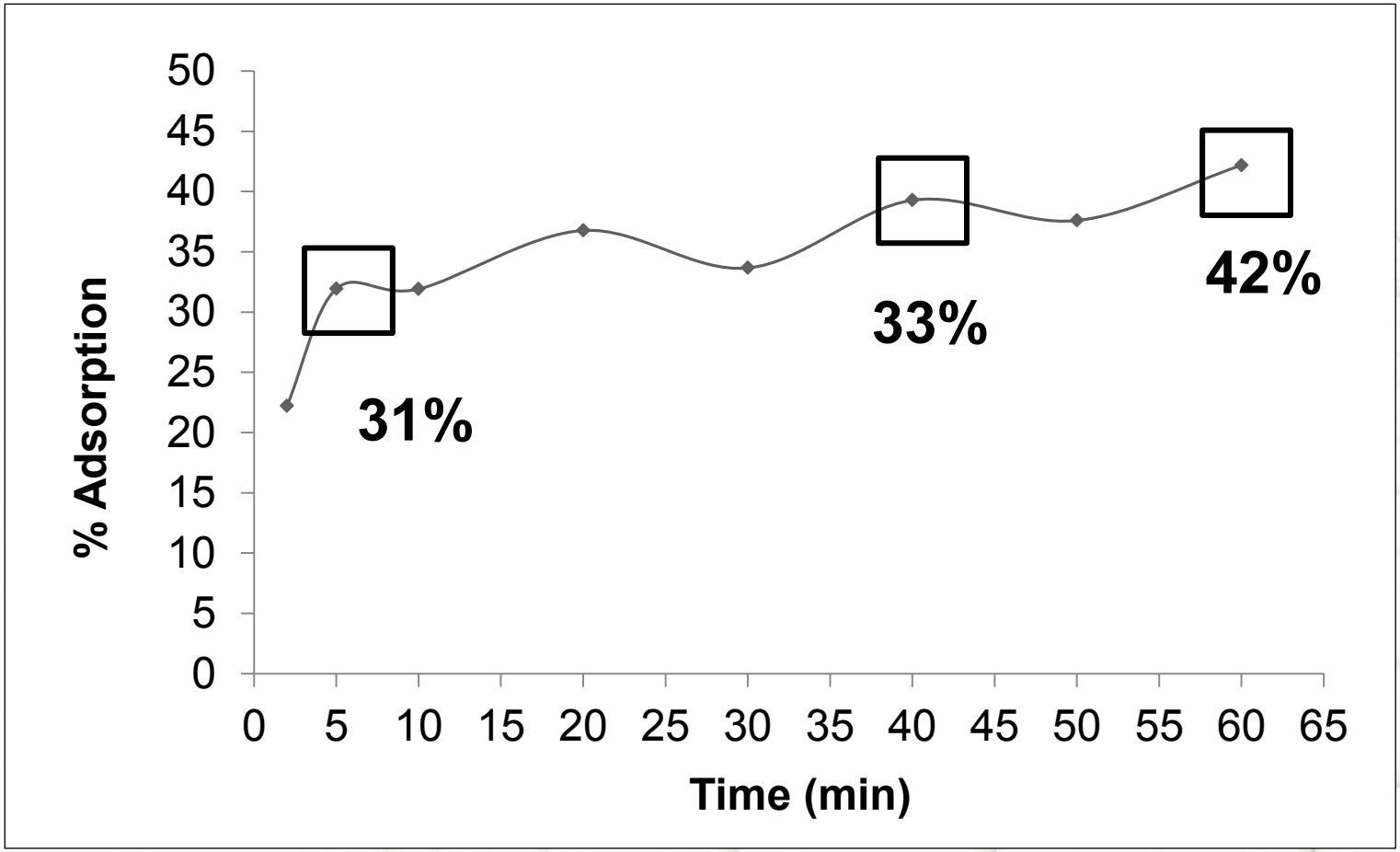
Adsorbents	Adsorption capacity ($mg\ g^{-1}$)
Modified MCM-41	290
MWCNTs modified with conducting organic polymers	176
O-MWCNTs	62.3
Functionalized mesoporous silica	0.197
Amberlite XAD-2000 resin	12.3
Functionalized activated carbon	32.3
Chemically modified activated carbon	33.6
Activated carbon immobilized dithizone phase	43.9

Adsorption Isotherm



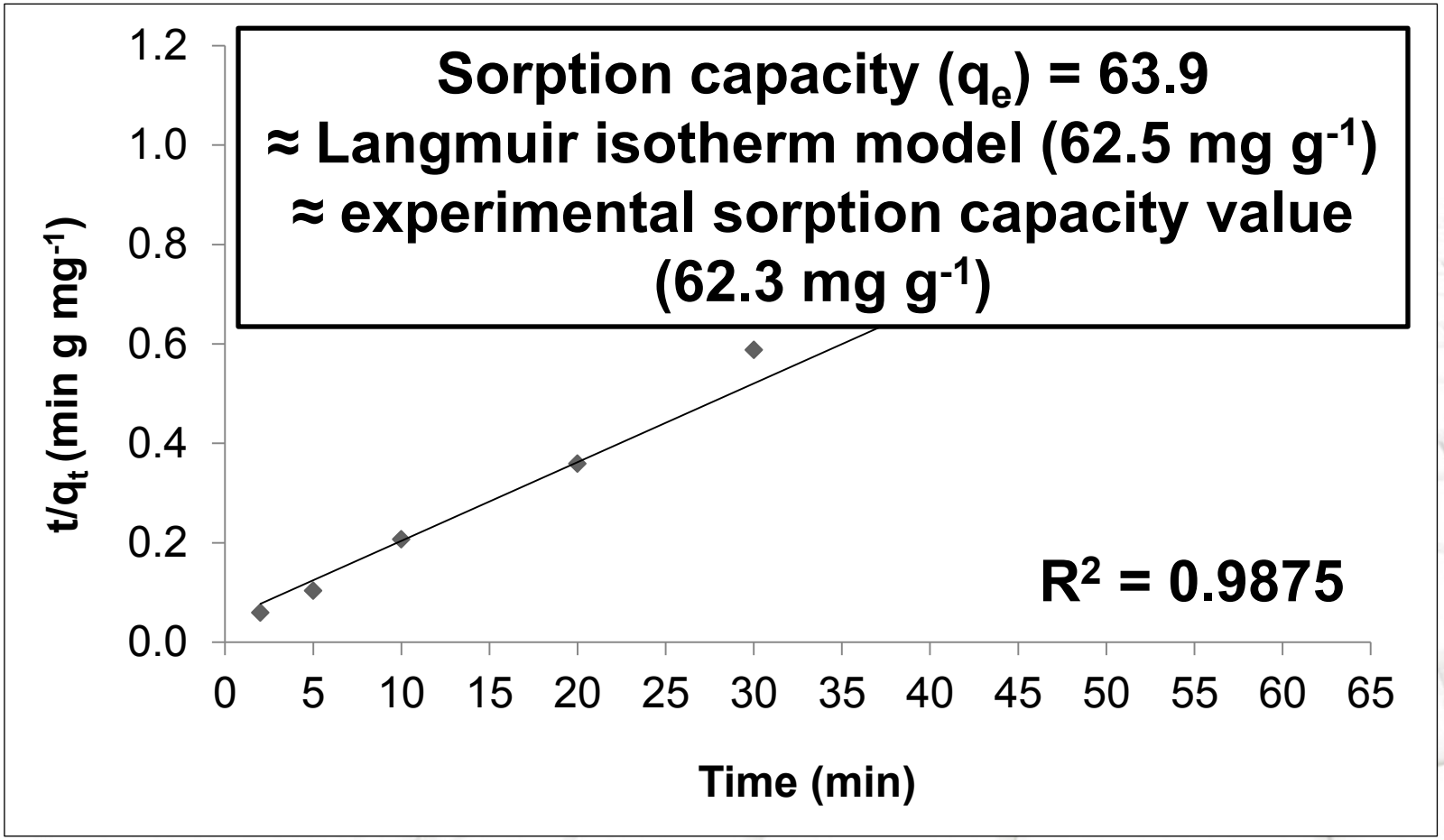
Langmuir isotherm model of Au(III) adsorption onto *O*-MWCNTs phase.

Effect of Contact Time



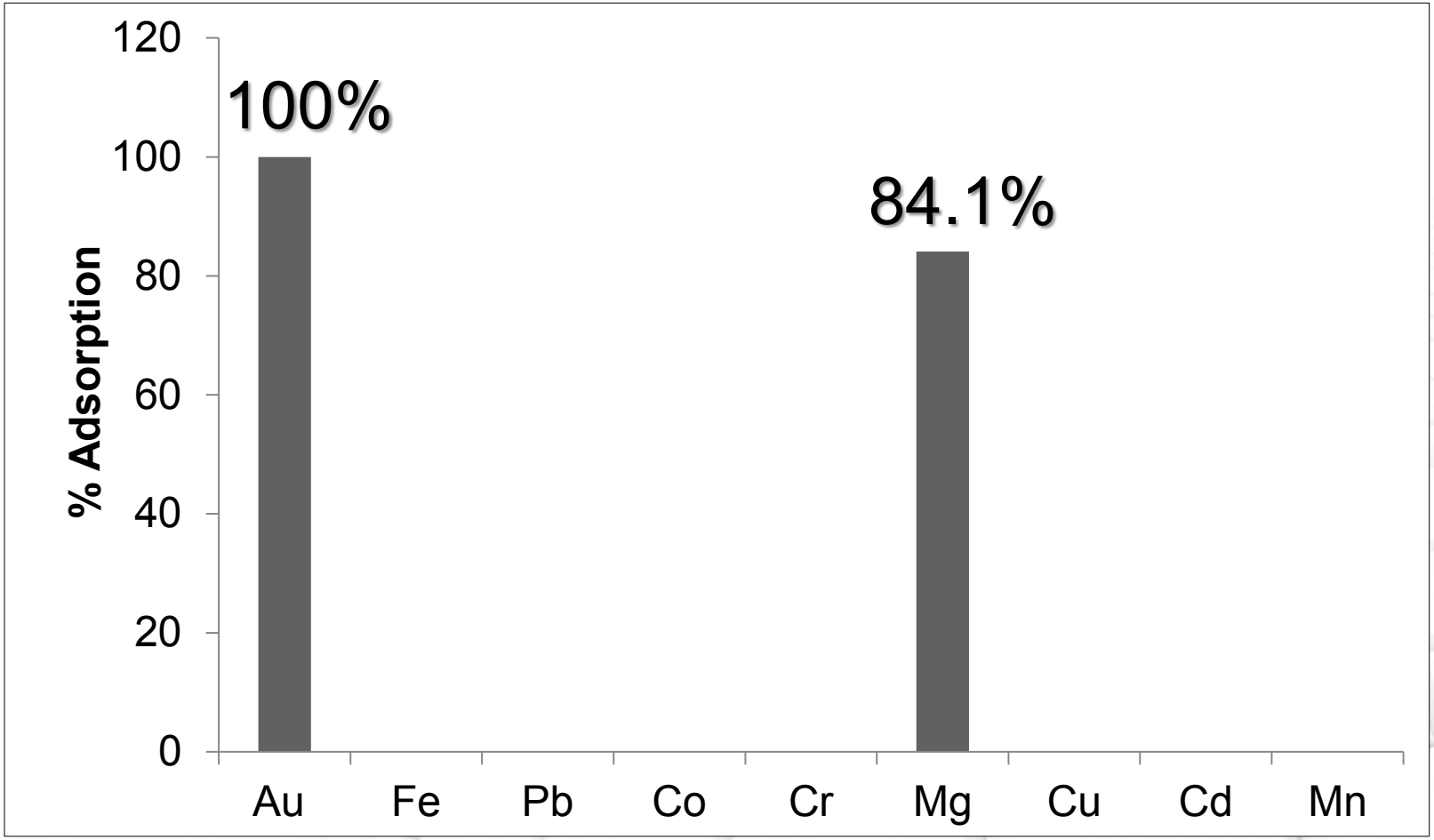
Effect of contact time on the adsorption of Au(III) onto *O*-MWCNTs phase at pH 2.0 and 25°C.

Kinetic Study



Pseudo second-order kinetic model of Au(III) uptake by adsorption onto *O*-MWCNTs phase at 25°C.

Effect of Coexisting Ions



Percentage adsorption of Au(III) and different metal ions using batch technique with 10 mg *O*-MWCNTs phase at pH 2.0 and 25°C (N=3).

Effect of Coexisting Ions

Distribution coefficient of Au(III) and different metal ions using batch technique with 10 mg *O*-MWCNTs phase at pH 2.0 and 25°C (N=3).

Binary metal ion mixture of Au(III) and other metal ion	K_d
Au(III)	$50x10^8$
Au(III)-Fe(III)	0
Au(III)-Pb(II)	0
Au(III)-Co(II)	0
Au(III)-Cr(III)	0
Au(III)-Mg(II)	$13.22x10^3$
Au(III)-Cu(II)	0
Au(III)-Cd(II)	0
Au(III)-Mn(II)	0

Application in Environmental Samples

Determination of Au(III) at different concentrations in real water samples using 10 mg *O*-MWCNTs phase at pH 2.0 and 25°C (N=3).

Environmental Samples	Au(III) added (mg L^{-1})	Adsorption (%)
Tap water	2	99.2
	5	99.34
	10	100
Sea water	2	99.9
	5	100
	10	100
Ground water	2	100
	5	100
	10	100
Waste water	2	100
	5	100
	10	100
Drink water	2	100
	5	100
	10	100

Conclusion

Finally, it can be concluded that:

- New solid phase extractor based on carbon nanotubes were successfully developed by physical functionalization.
- The newly *O*-MWCNTs showed excellent characteristics of investigated gold in terms of selectivity and adsorption capacity.
- Adsorption isotherm data of gold was presented by well defined models and found to be in agreement with adsorption isotherm experiments.
- The presence of different metals did not interfere on the adsorption of selected gold on the oxidized phase under optimum conditions.
- Finally, the method was found to be applicable in applying it to real environmental samples.

Acknowledgment



Prof. Hadi Marwani

Dr. Mohamed Abdel Salam

Prof. Ezzat Soliman

Every one who has helped me in this work and give me him advices, assistants and supports.

Acknowledgment



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Electron Microscope Unit

Center of Excellence for Advanced Materials


thank you
danke
謝謝
ngiyabonga
teşekkür ederim
gracias
спасибо
obrigado
bedankt
dziękuję
merci
go raibh maith agat
sukriya
kop khun krap
terima kasih
grazie
arigatô
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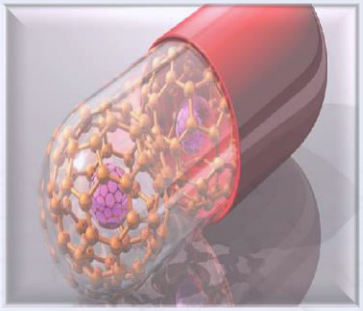
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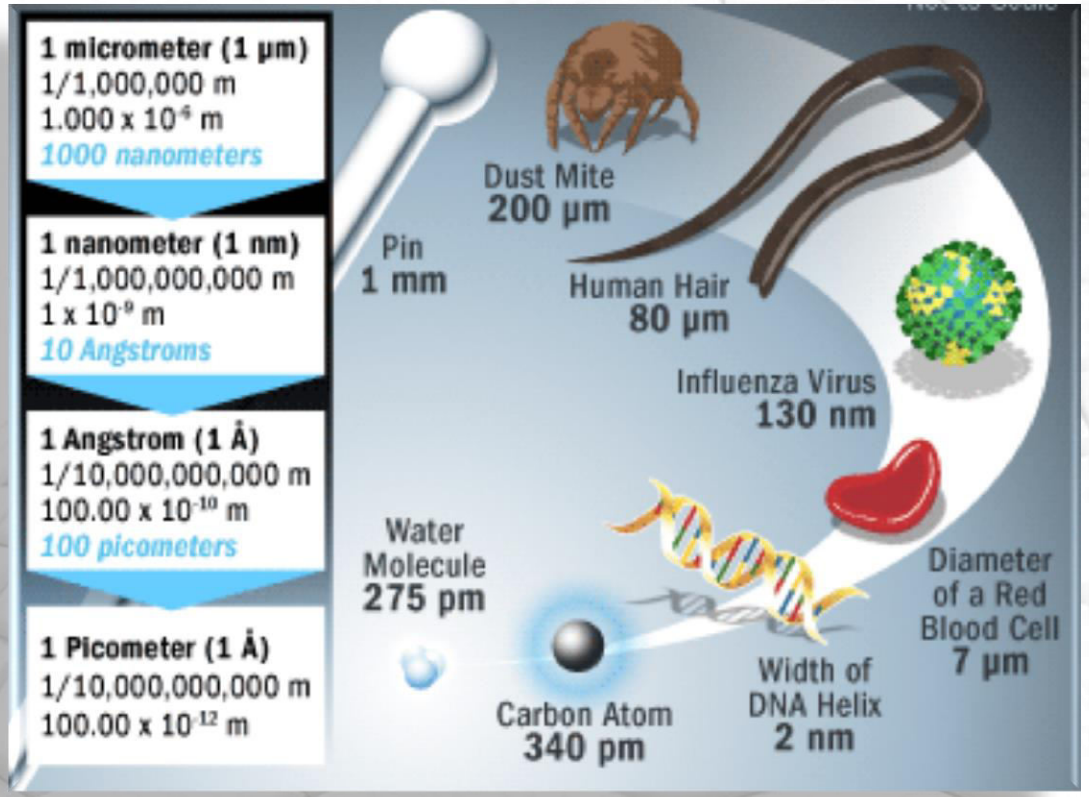


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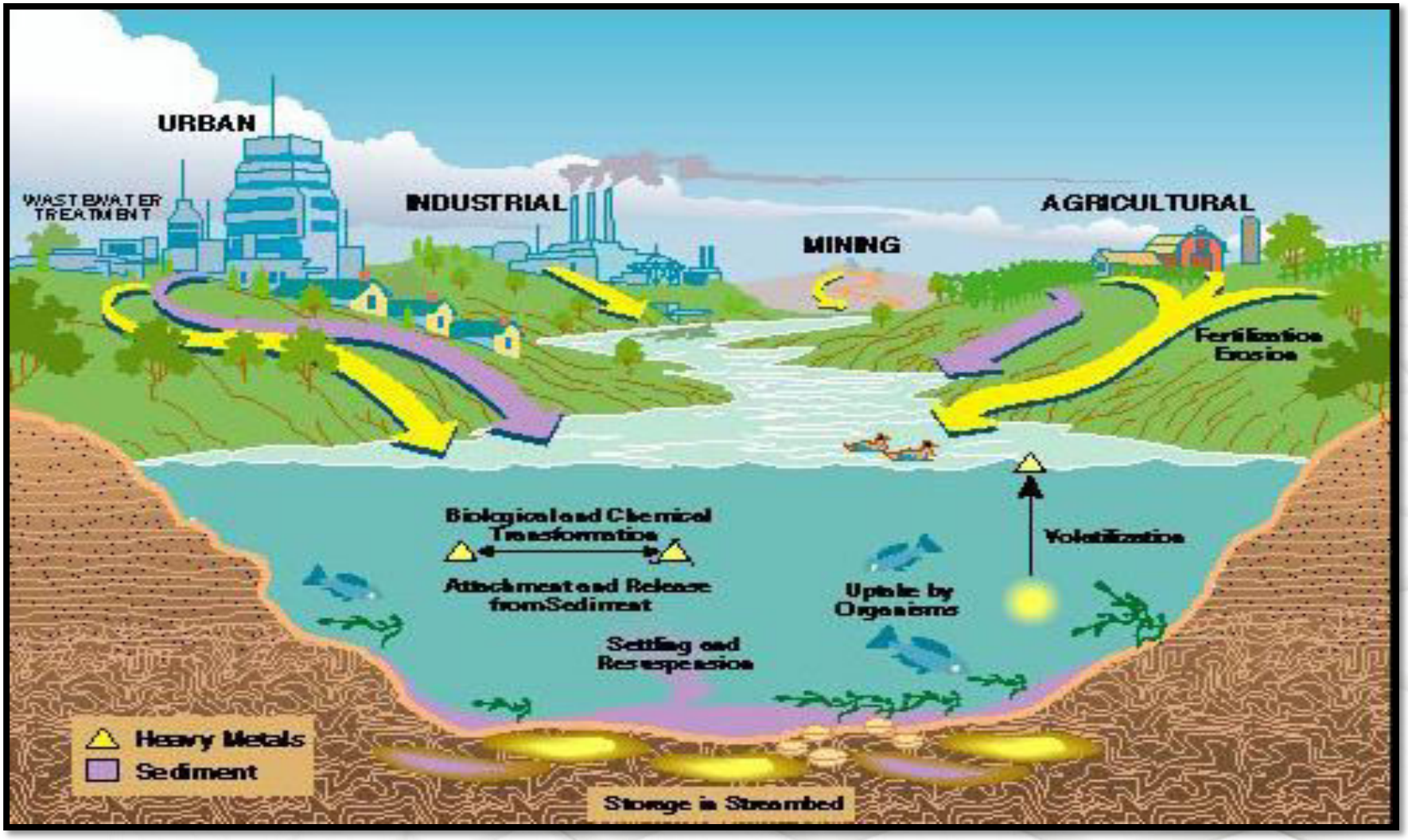
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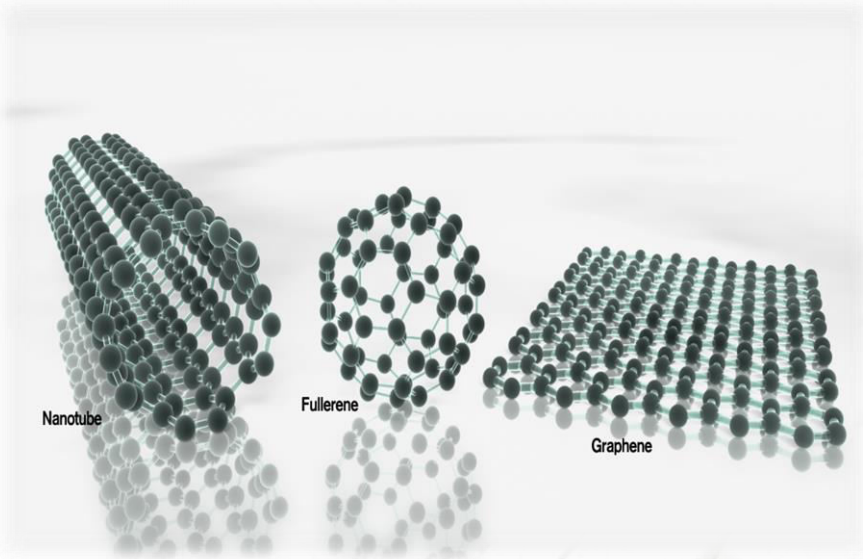
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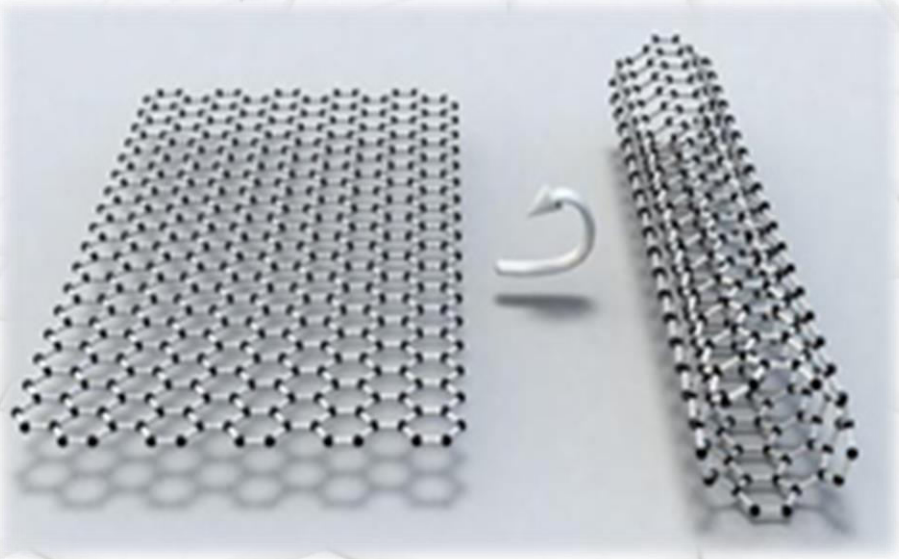


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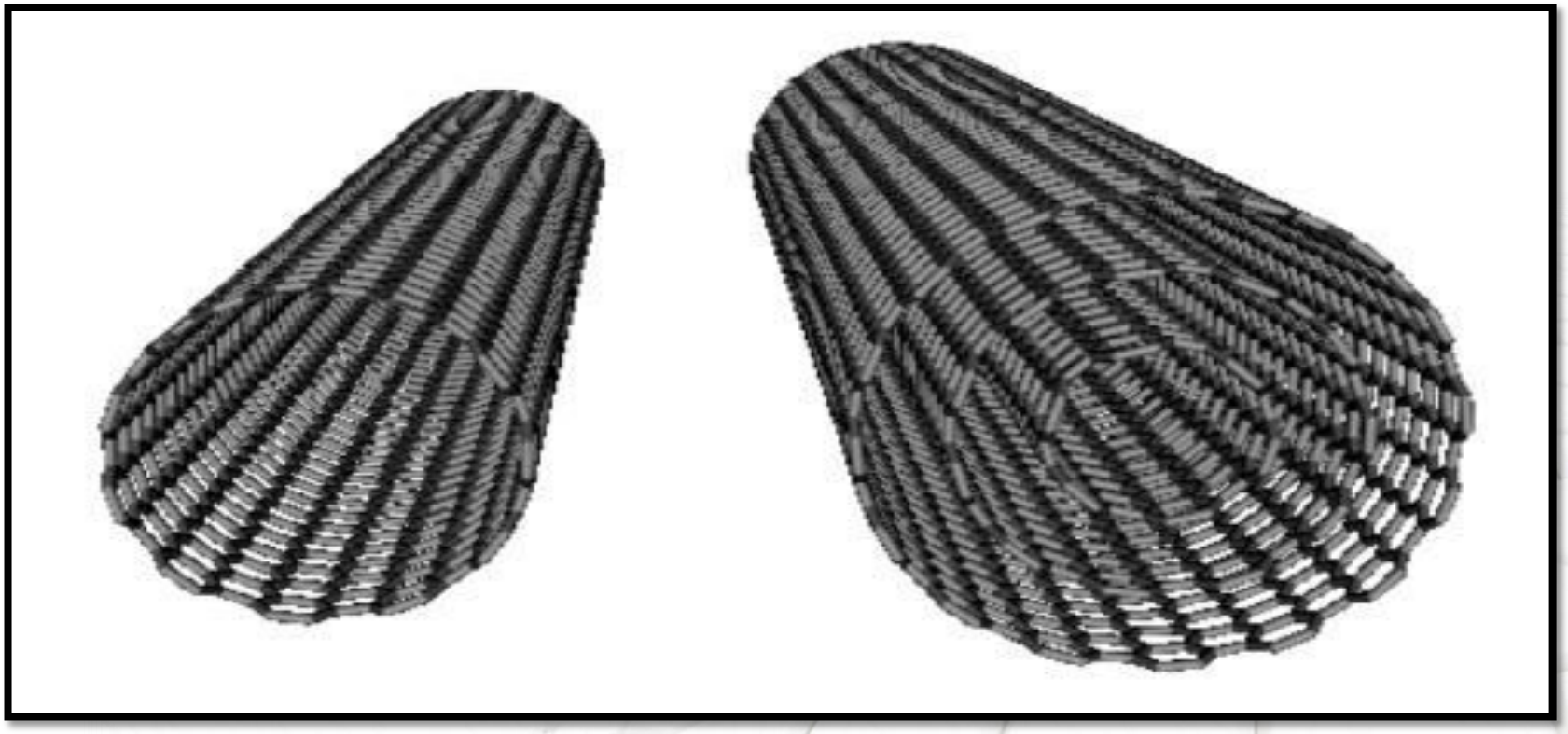
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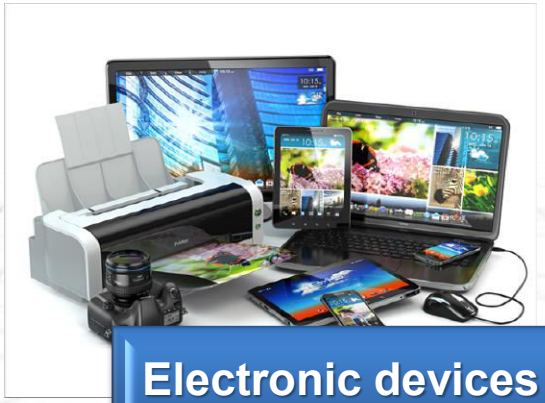
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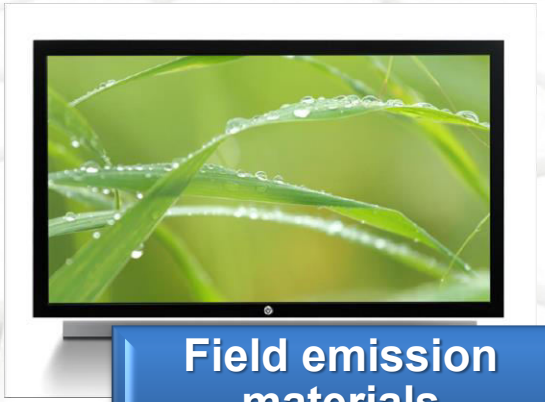
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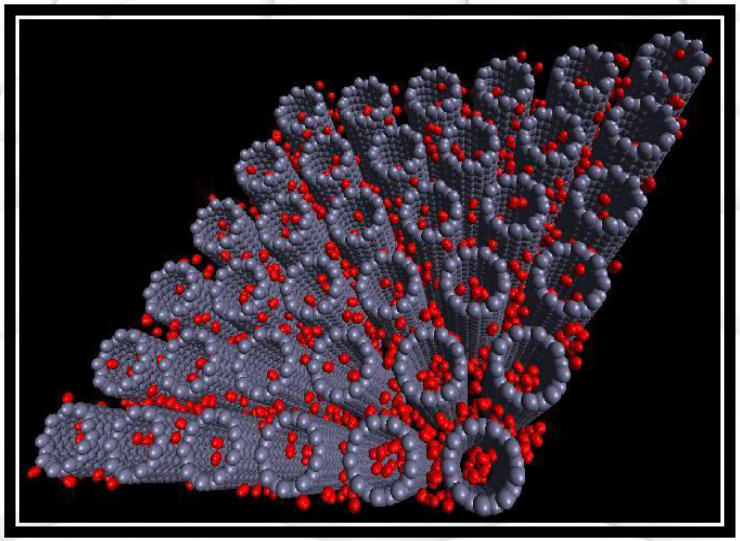
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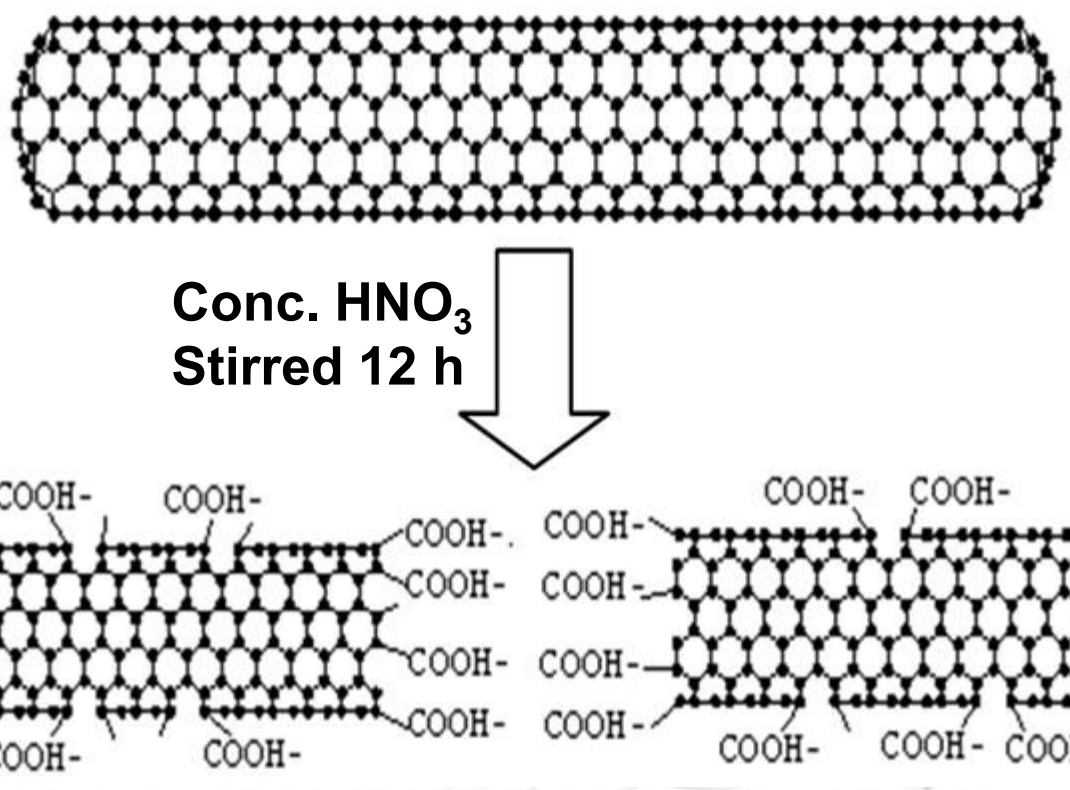
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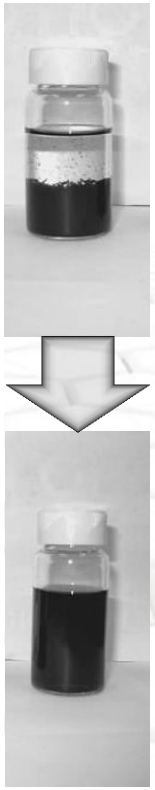
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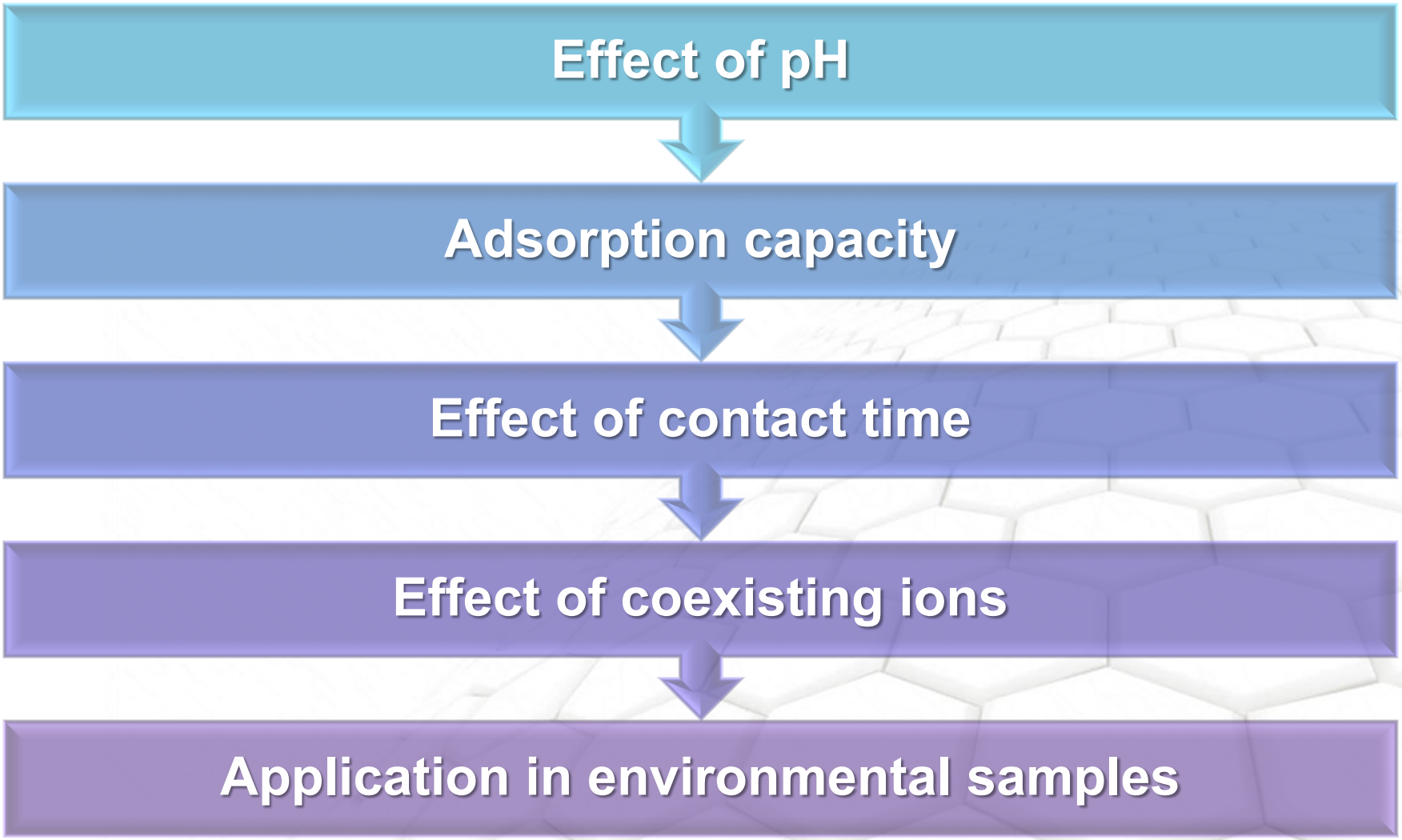
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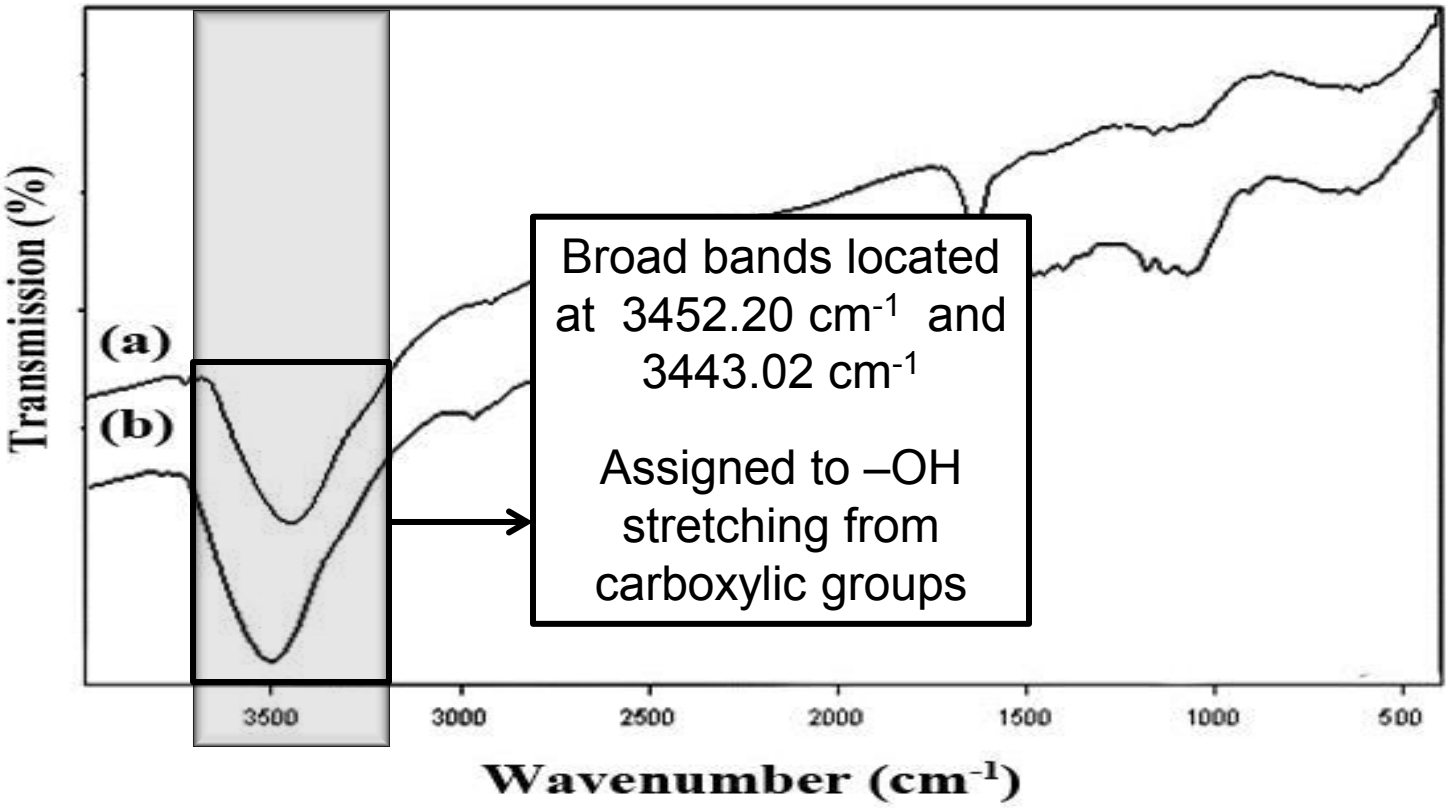
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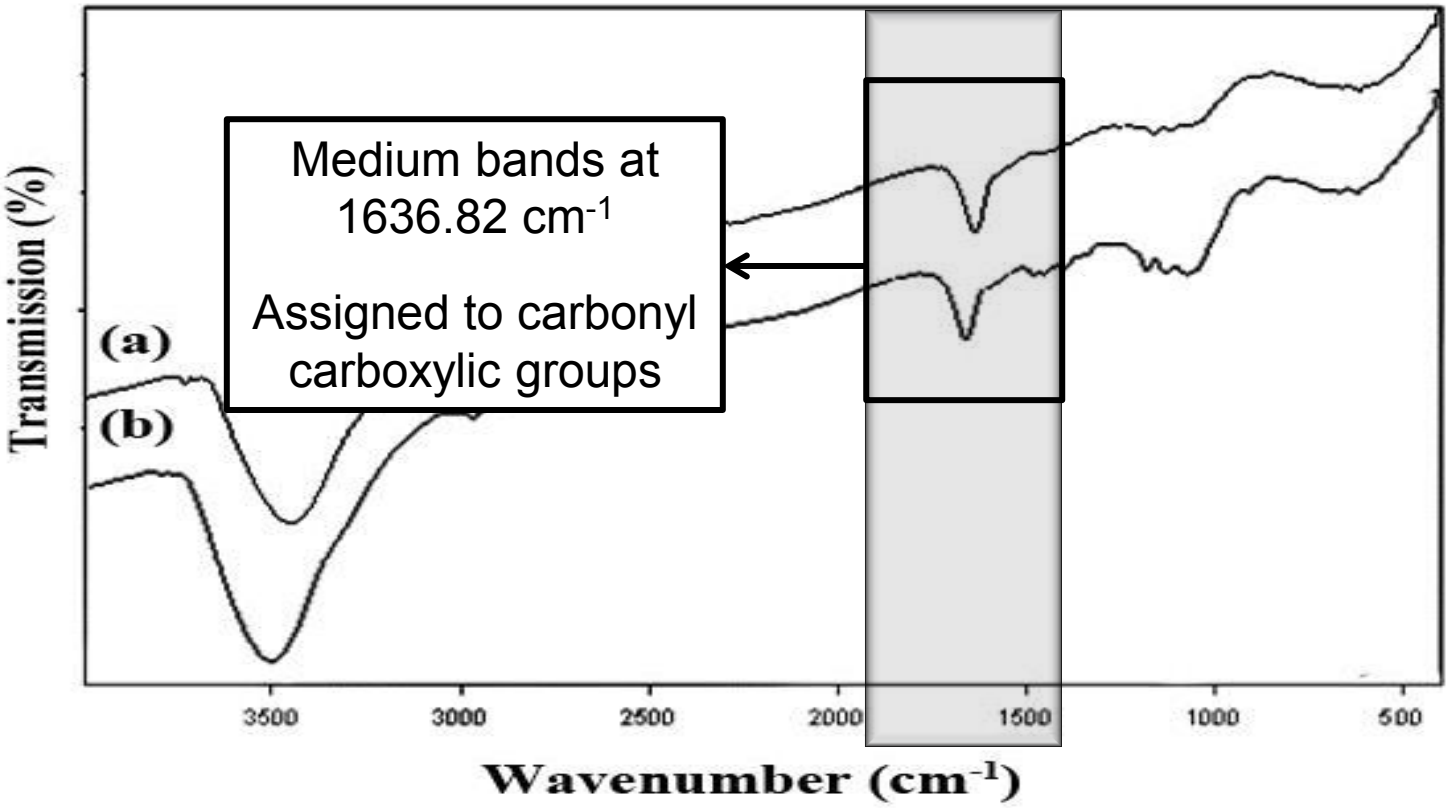
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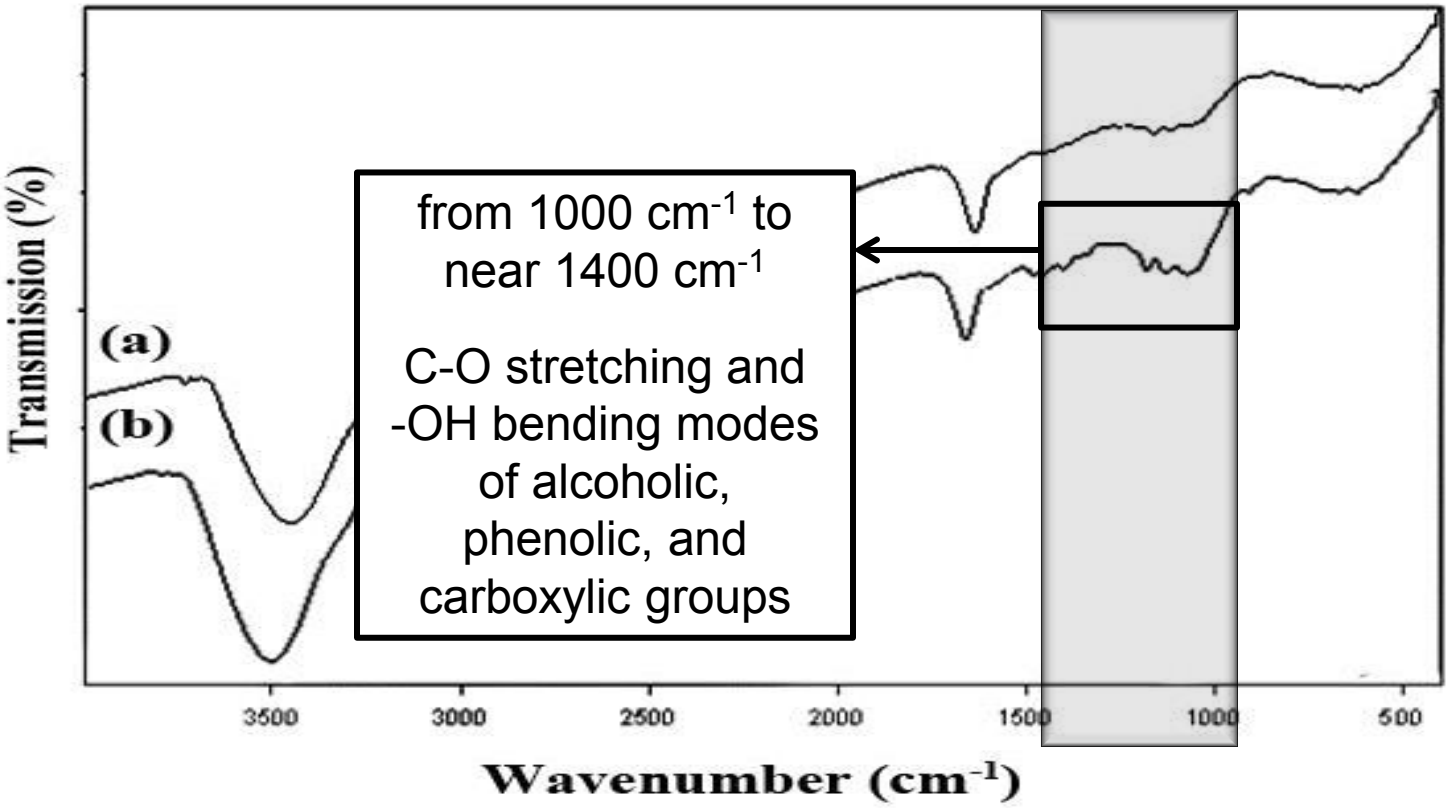
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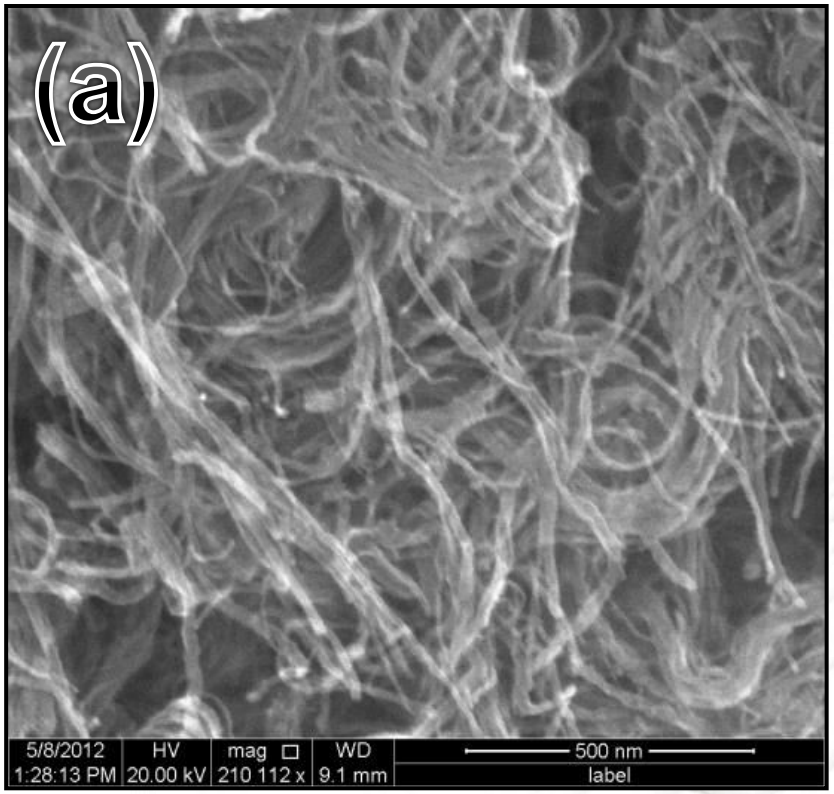
FT-IR

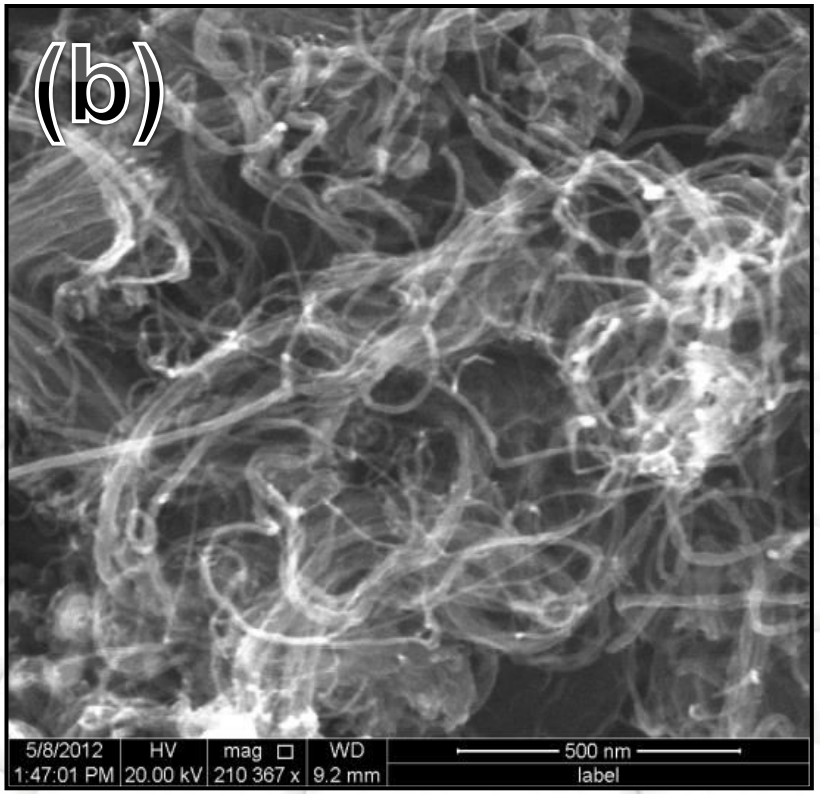


FT-IR spectra of (a) pristine MWCNTs and (b) *O*-MWCNTs.

Characterization of *O*-MWCNTs

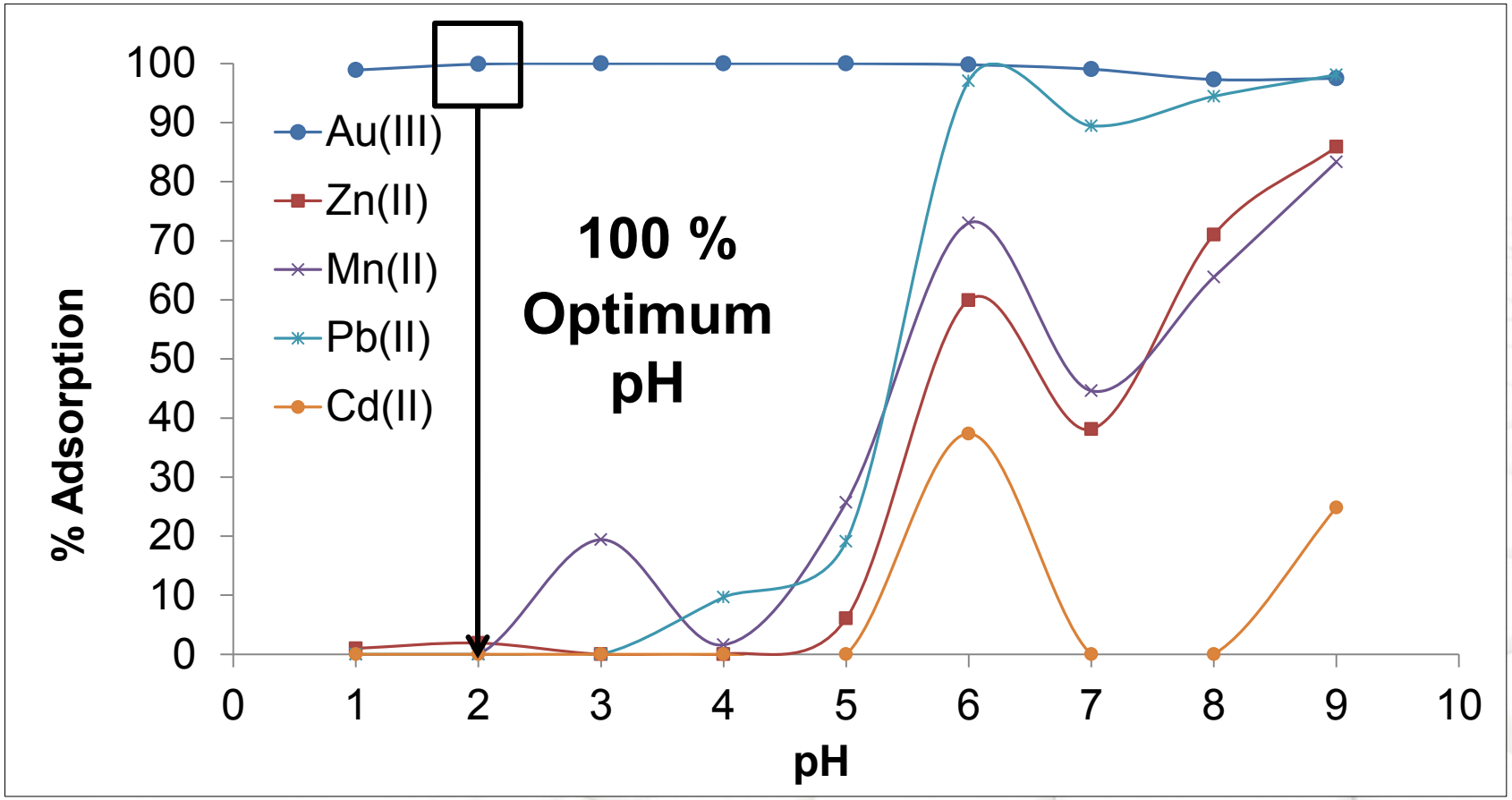
SEM





SEM images for (a) pristine MWCNTs and (b) *O*-MWCNTs.

Effect of pH

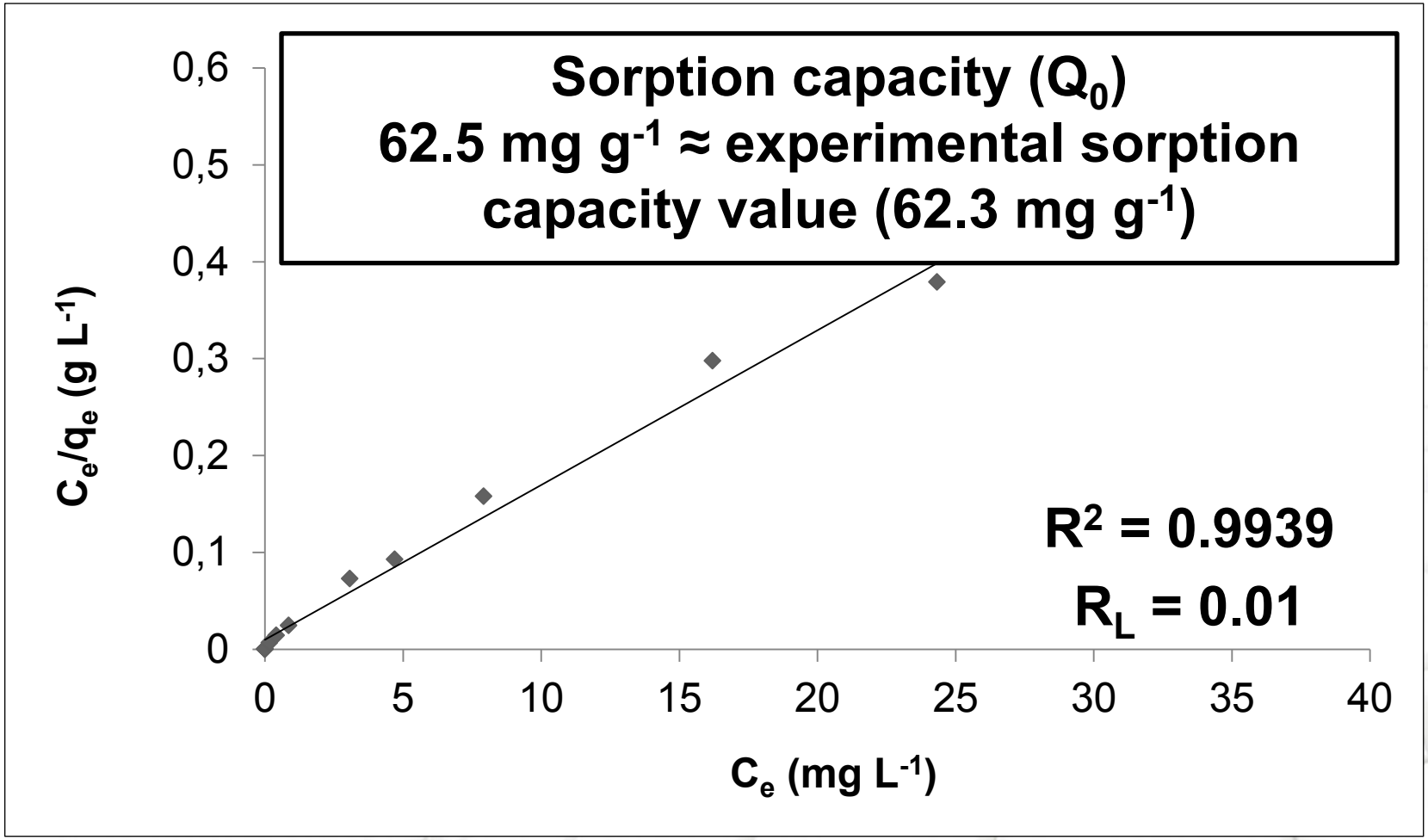


Effect of pH on the adsorption of 2 mg L^{-1} Au(III), Zn(II), Mn(II), Pb(II) and Cd(II) on 10 mg *O*-MWCNTs phase at 25°C.

Adsorption Capacity

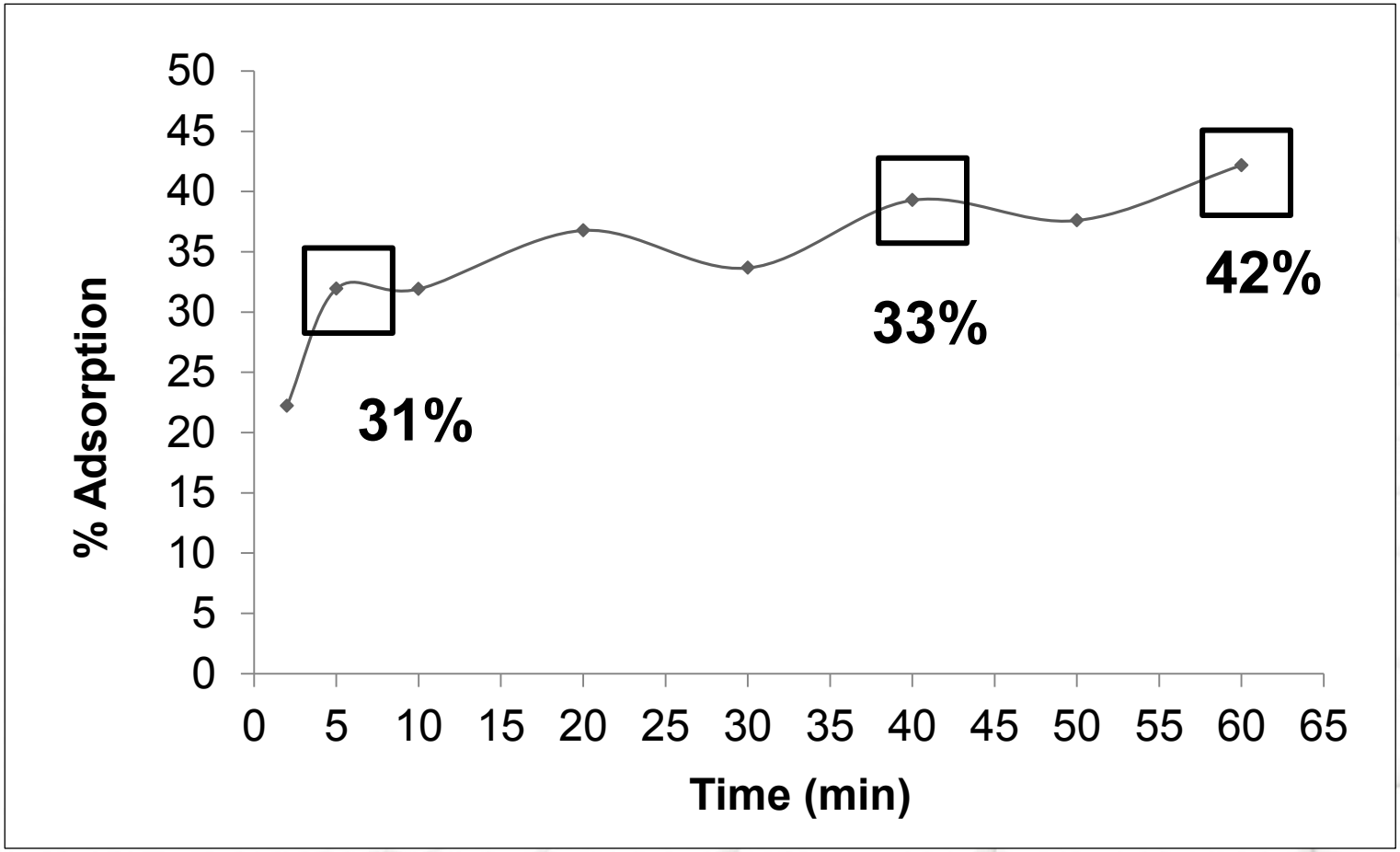
Adsorbents	Adsorption capacity ($mg\ g^{-1}$)
Modified MCM-41	290
MWCNTs modified with conducting organic polymers	176
O-MWCNTs	62.3
Functionalized mesoporous silica	0.197
Amberlite XAD-2000 resin	12.3
Functionalized activated carbon	32.3
Chemically modified activated carbon	33.6
Activated carbon immobilized dithizone phase	43.9

Adsorption Isotherm



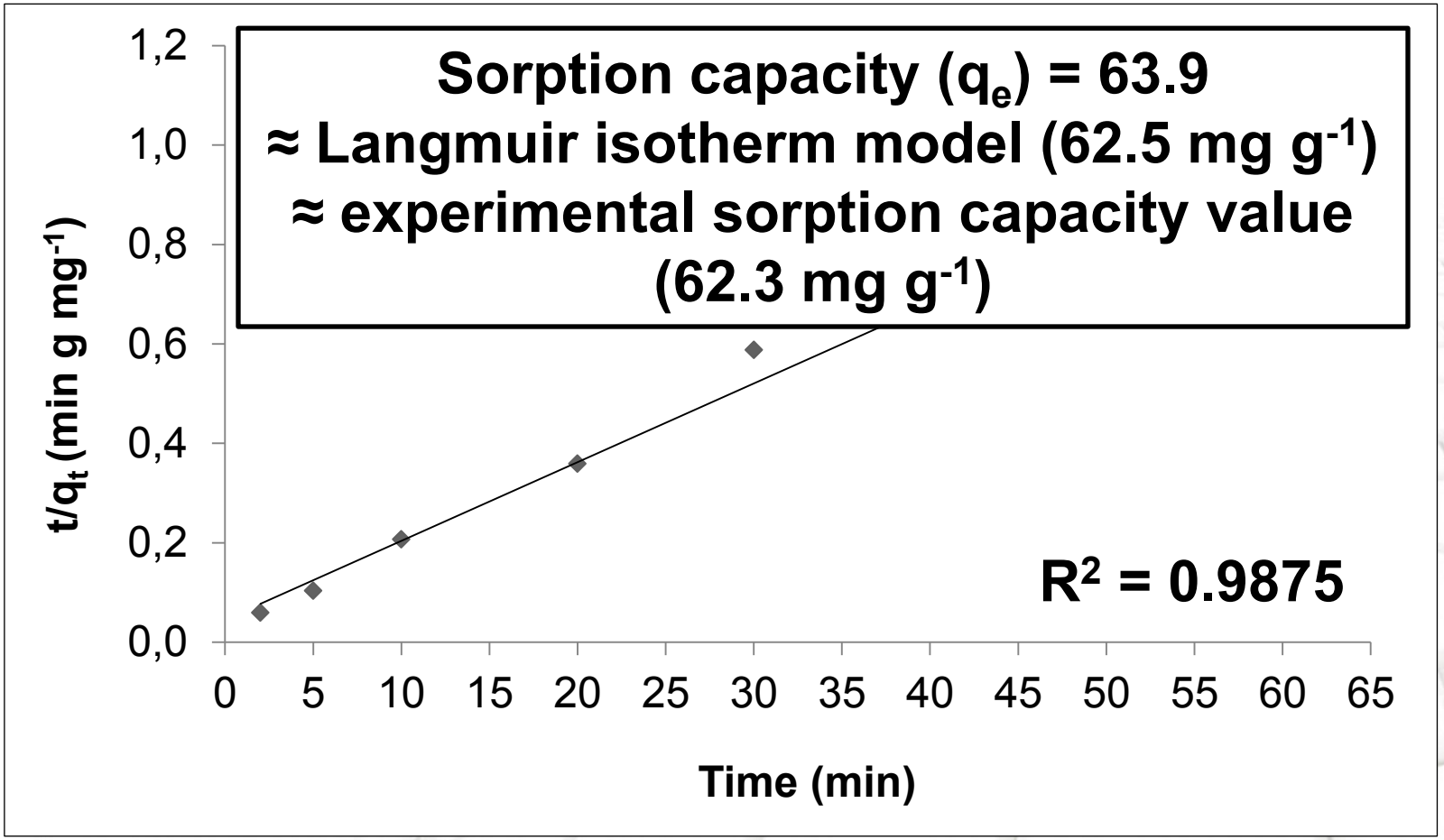
Langmuir isotherm model of Au(III) adsorption onto *O*-MWCNTs phase.

Effect of Contact Time



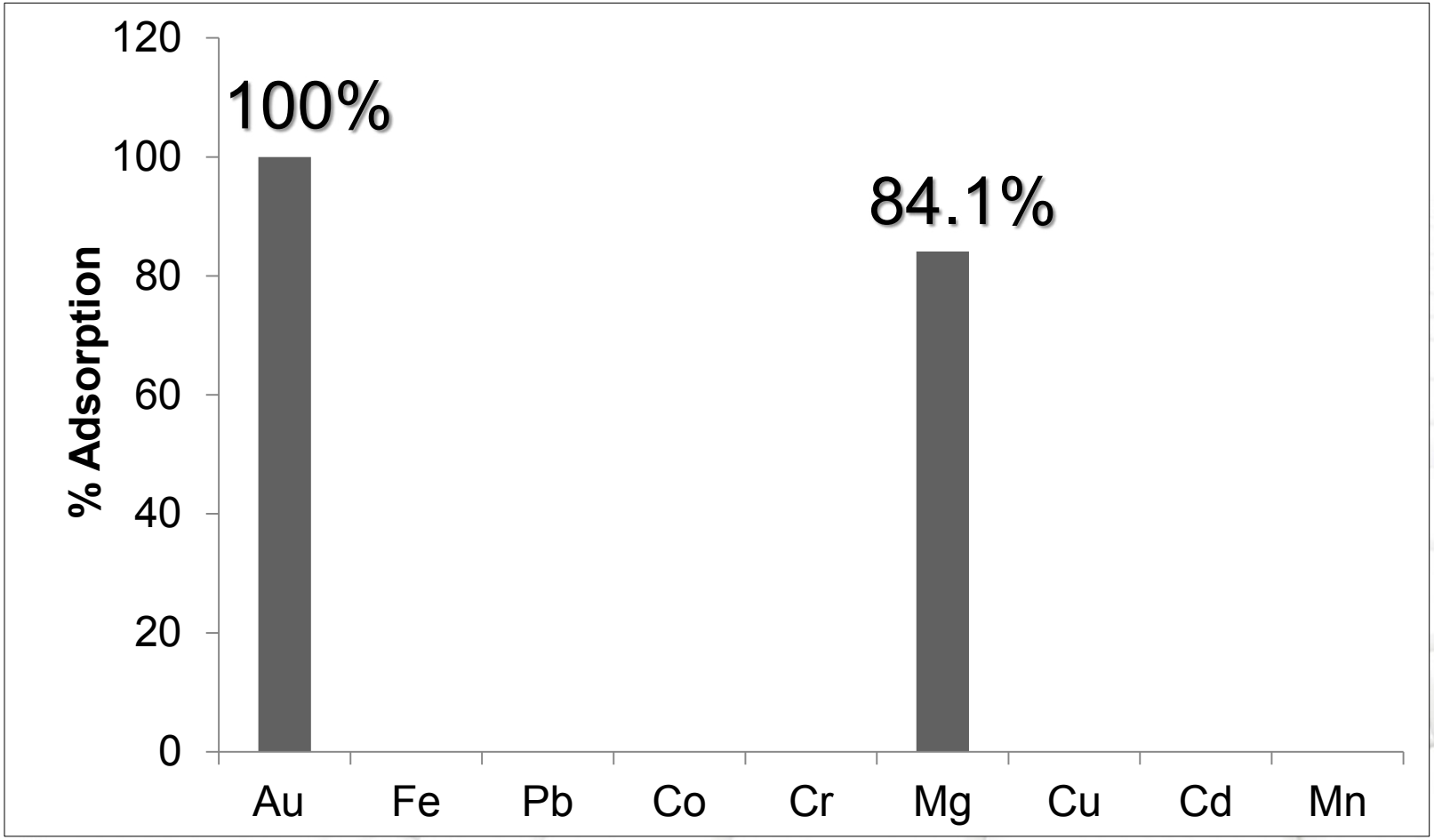
Effect of contact time on the adsorption of Au(III) onto *O*-MWCNTs phase at pH 2.0 and 25°C.

Kinetic Study



Pseudo second-order kinetic model of Au(III) uptake by adsorption onto *O*-MWCNTs phase at 25°C.

Effect of Coexisting Ions



Percentage adsorption of Au(III) and different metal ions using batch technique with 10 mg *O*-MWCNTs phase at pH 2.0 and 25°C (N=3).

Effect of Coexisting Ions

Distribution coefficient of Au(III) and different metal ions using batch technique with 10 mg *O*-MWCNTs phase at pH 2.0 and 25°C (N=3).

Binary metal ion mixture of Au(III) and other metal ion	K_d
Au(III)	$50x10^8$
Au(III)-Fe(III)	0
Au(III)-Pb(II)	0
Au(III)-Co(II)	0
Au(III)-Cr(III)	0
Au(III)-Mg(II)	$13.22x10^3$
Au(III)-Cu(II)	0
Au(III)-Cd(II)	0
Au(III)-Mn(II)	0

Application in Environmental Samples

Determination of Au(III) at different concentrations in real water samples using 10 mg *O*-MWCNTs phase at pH 2.0 and 25°C (N=3).

Environmental Samples	Au(III) added (mg L^{-1})	Adsorption (%)
Tap water	2	99.2
	5	99.34
	10	100
Sea water	2	99.9
	5	100
	10	100
Ground water	2	100
	5	100
	10	100
Waste water	2	100
	5	100
	10	100
Drink water	2	100
	5	100
	10	100

Conclusion

Finally, it can be concluded that:

- New solid phase extractor based on carbon nanotubes were successfully developed by physical functionalization.
- The newly *O*-MWCNTs showed excellent characteristics of investigated gold in terms of selectivity and adsorption capacity.
- Adsorption isotherm data of gold was presented by well defined models and found to be in agreement with adsorption isotherm experiments.
- The presence of different metals did not interfere on the adsorption of selected gold on the oxidized phase under optimum conditions.
- Finally, the method was found to be applicable in applying it to real environmental samples.

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merci
go raibh maith agat
sukriya
kop khun krap
terima kasih
grazie
arigatô
dakujem
мерси
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