



#### esign of an efficient raphene-based composite for pharmaceutical removal from water

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# imof \esearch



Schematic: Pollutant degradation mechanism of TiO2/Graphene composite. Photograph: The contrast of effluent (left) and influent (right) of a wastewater treatment plant. Photograph: Zahra Gholamvand

# Water purification under threat: pharmaceuticals in our drinking water

#### By Zahra Gholamvand

Photocatalysis as an advanced technology for pharmaceutical removal from water

German scientists<sup>1</sup> were the first to report finding more than 30 different pharmaceuticals in surface waters. Since then, other industrialized countries have started to test In this regard, photocatalysis is a promising supplement to conventional treatment systems. In this process the absorption of high energy photons produces electrons and



# nt r oduct i on



## Olution: dvanced ertiary reatment







# hot ocat al ysi s

#### dvant ages

- o chemical or consumable
- o sludge production
- o cat al yst regenerat i on
- %r ecover abl e
- \elatively short retention time
- or energy use
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- nonwolbiilghsti negiftihoe erratyal (ysrtay water)
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# Olution: ntegration with raphene

- lack (blocking)
- ydrophobi c
- p. dependent
- ot accessi bl e por es







<u>i m</u>

esigning a graphene base platformfor i integration





#### dsorpt i on by



#### dsorpt i on by







#### dsorpt i on

- Functional groups
- Pi-Pi interaction
- Porosity and surface area







#### dsorpt i on

- Functional groups
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- Porosity and surface area







Properties	GO	HRGO
BET surface area $(m^2/g)$	547.37	345.92
Pore volume cc/g (size< 66nm)	2.366	1.7
Average pore radius nm	8.64	9.87
BJH desorption pore radius nm	1.89	2.039

Sample	BET surface area (	$(m^2/g)$ MB surface area $(m^2/g)$
Relative Graphene oxide	547.37	2605.5
Reduced graphene oxide	345.92	2210.2

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#### hot ocat al ysi s

- Dimensionality of TiO<sub>2</sub> nanostructure is an important factor on efficiency and mechanism of photocatalysis
- Surface area
- Synthesis method (sol-gel, hydrothermal, ...)
- Electron transfer mechanism
- Pore size



3D

Nanotubes

Hierarchical

beads

1D

Nanofibres

Nanoparticle

# **\esults:** hot ocat al vsi s



# hot ocat al ysi s





#### **\esults:** hot ocat al ysi s

- HPLC method for diclofenac and carbamazepine were optimised to get better peak separation
- 0.3 g/L composite showed 80% degradation of 50 ppm diclofenac after 70 min and almost 100 % after 120 min





### Photocatalytic degradation of diclofenac by hydrothermally synthesised $TiO_2/GO$

### **\esults:** hot ocat al ysi s

• In-situ hydrothermally synthesized TNTs on graphene oxide shows excellent photocatalytic activity towards famotidine degradation under UV and visible light (sample D1)





#### esults: hot ocat al ysi s

dvant ages of i/ composites

- Easy post separation process
- Reusable
- High surface area around 350 m<sup>2</sup>/g comparing  $60 \text{ m}^2$ /g for P25
- Higher UV efficiency comparing activated carbon/TiO<sub>2</sub> composite
- Higher photocatalytic activity comparing  $\text{TiO}_2$  and other types of  $\text{TiO}_2$  composites
- UV re-generation capability
- High adsorption capacity for dyes and organic molecules with benzene ring
- Easy processing to produced different forms of composite such as thin and thick film, powder, solution and granule









# hanks to:

EnvironTech DCU Environmental Technology Research Group





### **esults:** dsorptio

- Immobilizing GO on different substrates
- Dolomite/ GO showed the highest adsorption
- MB adsorption for proof of concept
- High adsorption of different dyes with benzene ring but not great ability to adsorb pharmaceuticals with long tail such as famotidine
- ➤ This material can be a used to remove dyes form wastewater









UV/vis spectra of 6 pharmaceutical compounds in water before and after adsorption by GO



•40 % adsorption of 100 ppm mixture of Metoprolol, ibuprofen, propranolol, salbutamol, salicylic acid and diclofenac instantly after mixing and 70% after 30 min
•Adsorption of 50% of carbamazepine instantly and 100 % after 30 min

• 100% adsorption of MB and methyl orange dyes after 5 min



### ∖esults: dsorption

- ption
- High porosity and surface area 2500 m<sup>2</sup>/g based on MB adsorption
- $\pi = \pi$  interaction between benzene ring of GO and pollutant
- Adsorption by different **functional groups** on GO basal plane (FTIR spectra)
- Lowering the surface free energy of sheets by stacking with other molecules

