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Chitosan-based biocomposites as H_2S vehicles

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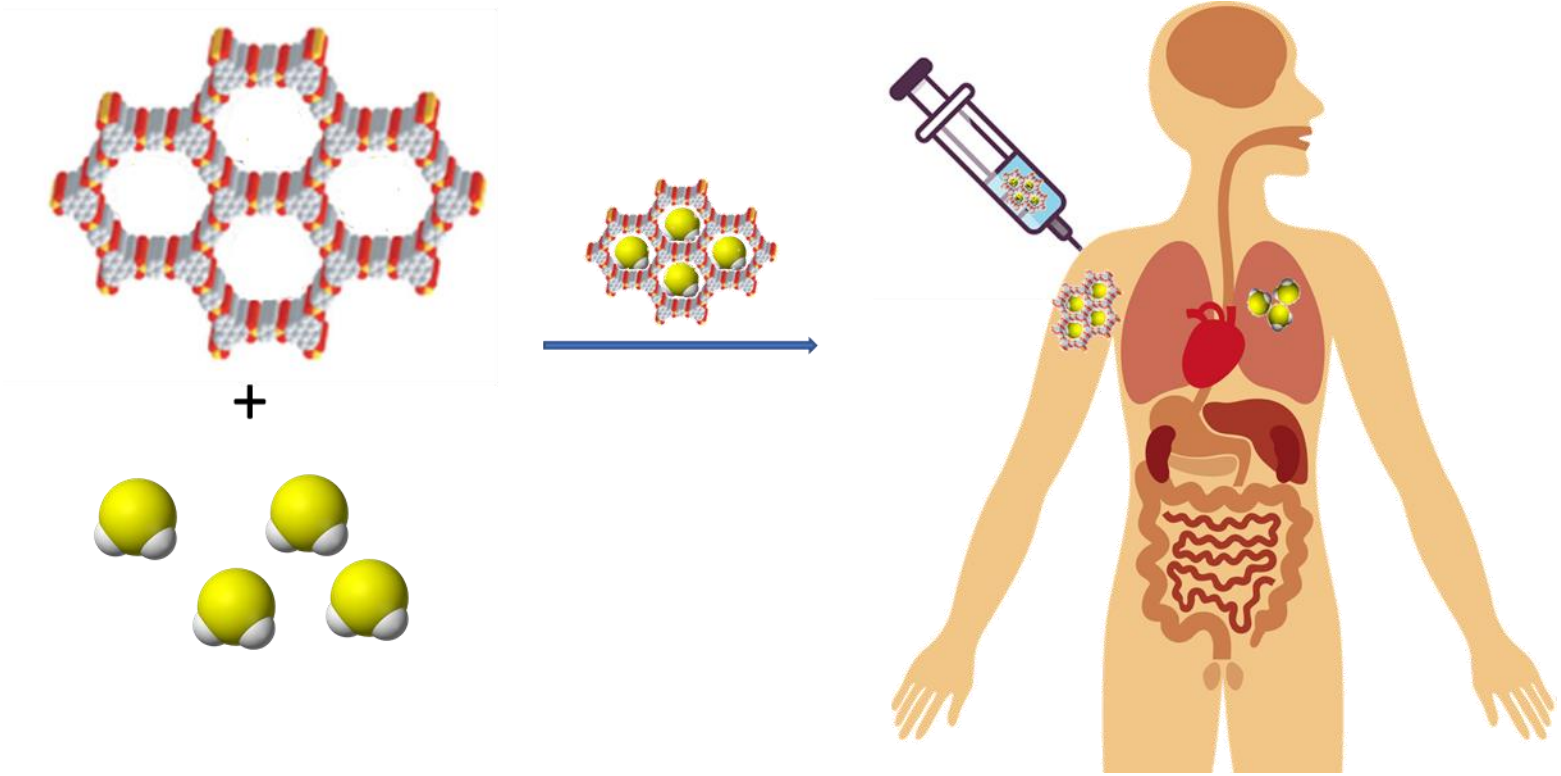


Abstract

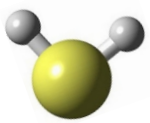
Hydrogen sulphide (H_2S) is commonly known due to its toxicity, and rotten egg smell, yet the detection of endogenously produced H_2S in the brain tissues of mammals in 1989 changed the ways scientists looked at this gas. Currently, H_2S is a gasotransmitter (small gaseous molecules involved in signalling processes) and its exogenous delivery has many potential therapeutic applications (*e.g.*, wound healing, cardiovascular diseases). The therapeutical use of H_2S is challenging, being crucial maintaining its level in the body within the therapeutic window, at the risk of having toxic effects.

In this work, we synthesised chitosan biocomposites using porous materials (type A zeolites and an activated carbon obtained from glycerine) and conducted studies to evaluate the possibility of being used as H_2S vehicles. The biocomposites were characterised and their H_2S adsorption capacity and release profile in aqueous solution at pH 7 were evaluated by volumetric method and Ellman´s reagent, respectively. Cytotoxicity assays using HeLa cells for all chitosan biocomposites were performed, as well as for the H_2S loaded material that showed the most promising aqueous solution release results.

Keywords: biocomposites; chitosan; H_2S vehicles

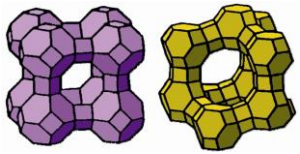
Introduction

H_2S



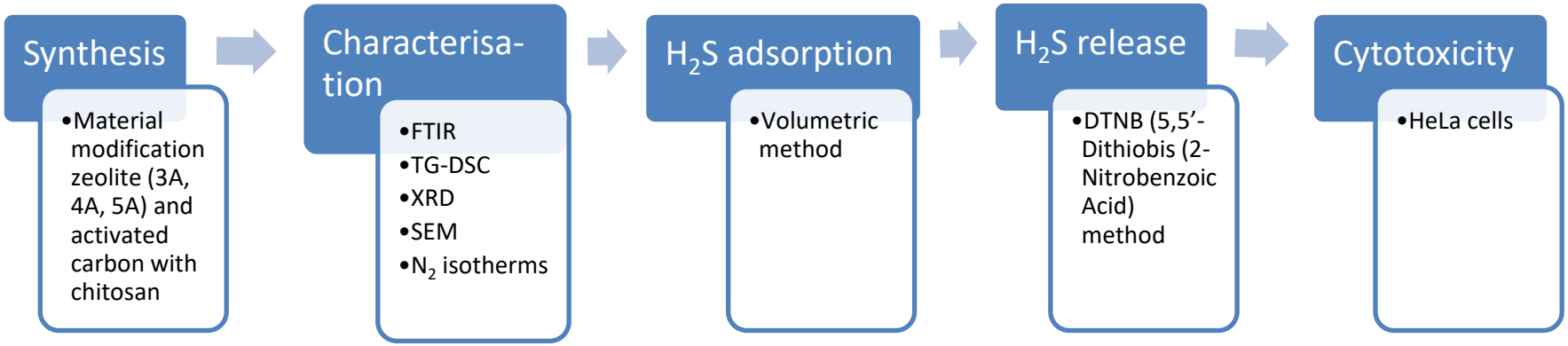
- H_2S is commonly known by its rotten-egg smell and high toxicity;
- However, it is a gasotransmitter and it may have therapeutic applications;
- This application is limited due to delivery problems.

Porous materials



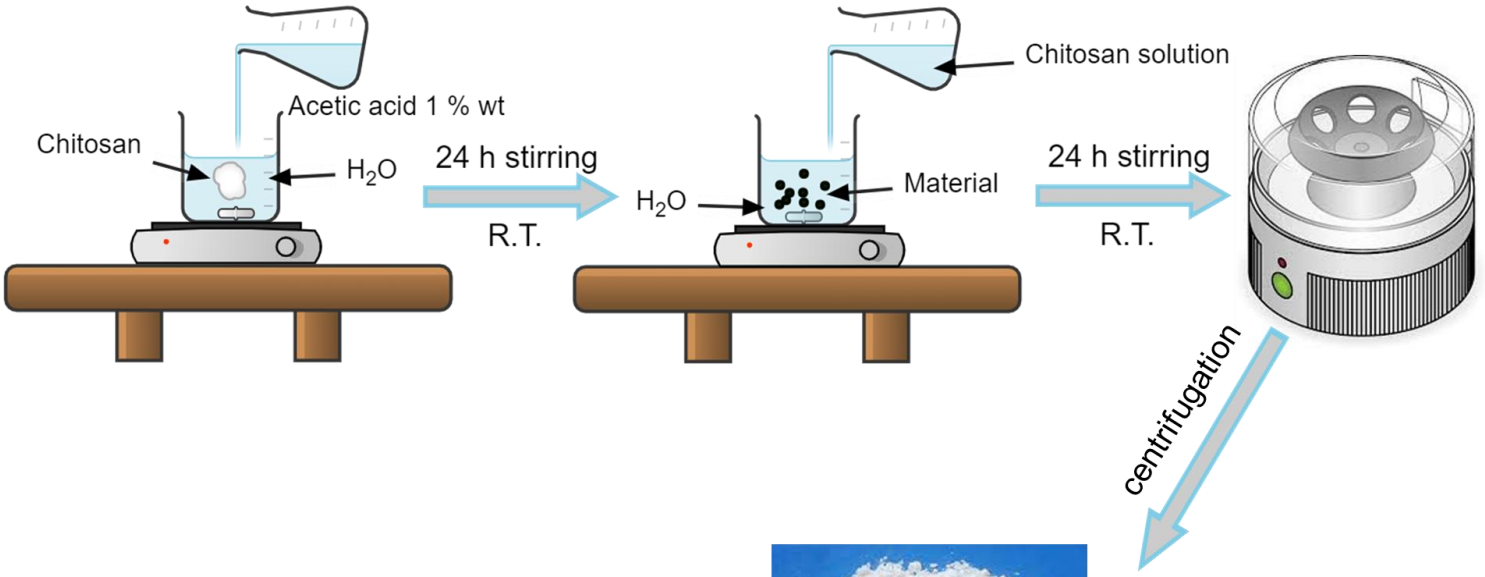
- Porous materials are solid containing void space;
- Their high surface area led to a high gas payload;
- In recent years, they have been investigated as potential drug vehicles;
- Biocompatibility issues may be overlapped by surface modification with biocompatible polymers.

In this work:


Synthesis
•Material modification zeolite (3A, 4A, 5A) and activated carbon with chitosan
Characterisa-tion
•FTIR
•TG-DSC
•XRD
•SEM
•N_2 isotherms
H_2S adsorption
•Volumetric method
H_2S release
•DTNB (5,5'-Dithiobis (2-Nitrobenzoic Acid) method
Cytotoxicity
•HeLa cells

Results and discussion

Synthesis

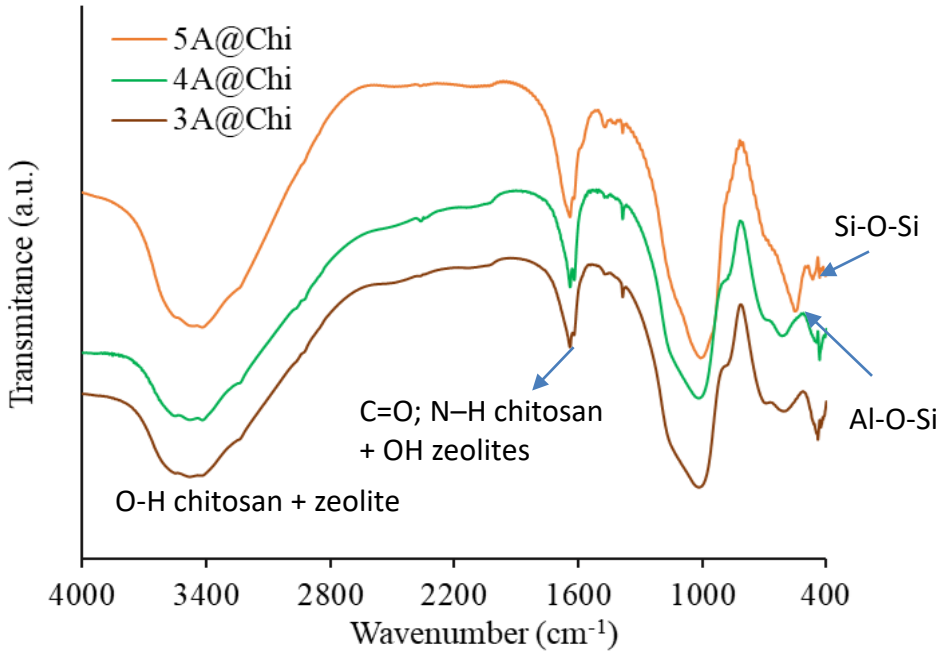


Activated carbon biocomposite

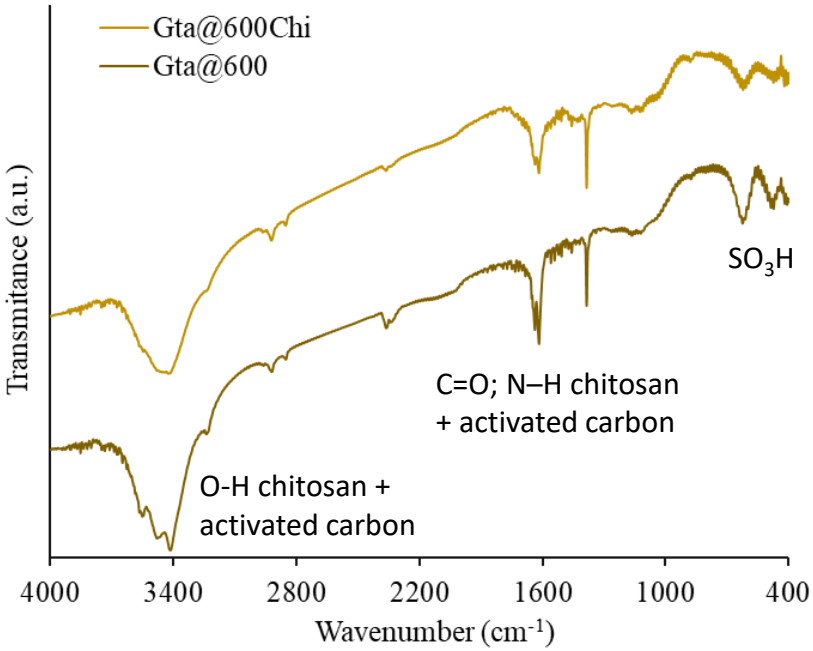
Zeolite (3A, 4A and 5A) biocomposites

Characterisation - FTIR

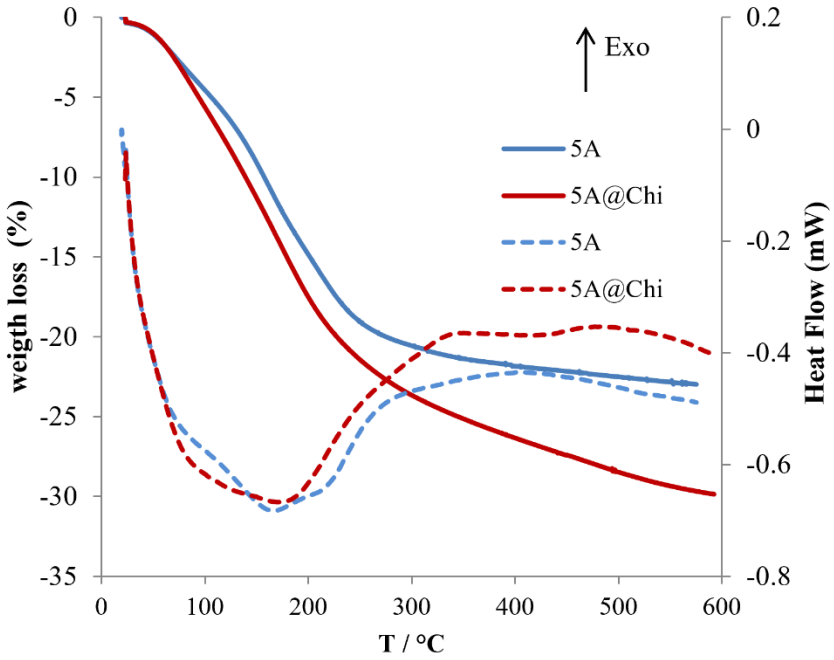
Zeolites composites

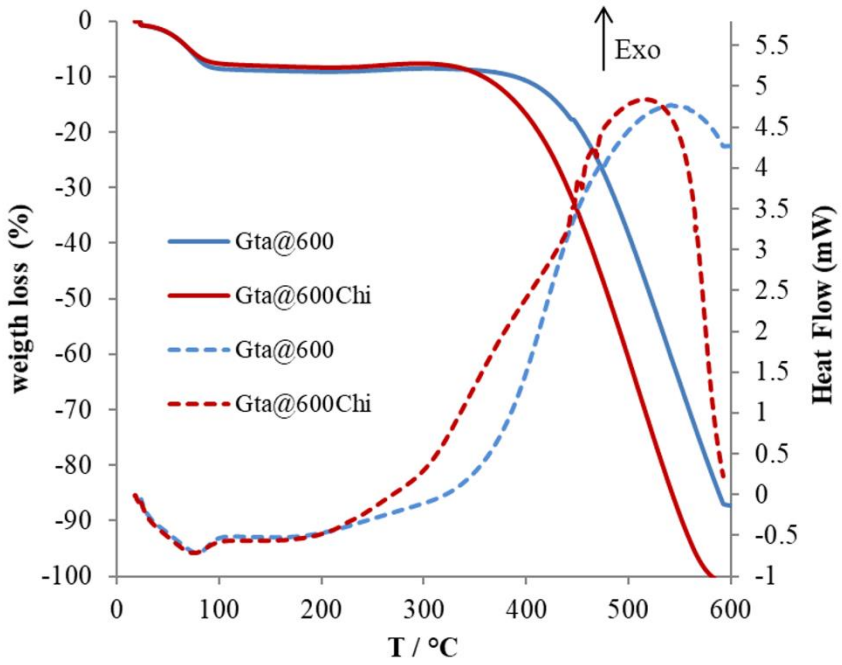


Activated carbon materials



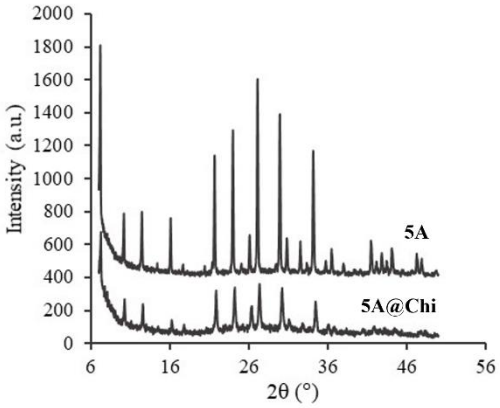
Characterisation - TG-DSC



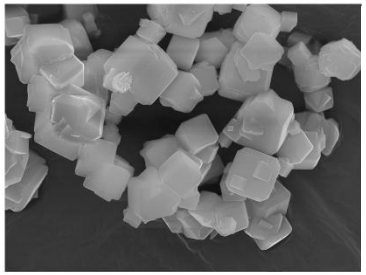


Sample	Parent material		Material with Chitosan		Chitosan (%)
	225 °C	525 °C	225 °C	525 °C	
3A	16.5	20.7	16.9	26.1	5.4
4A	17	21.6	17.9	28.4	10.5
5A	17.3	22.7	19.8	28.9	9.1
Gta@600	9.1	53.1	8.3	75.6	23.3

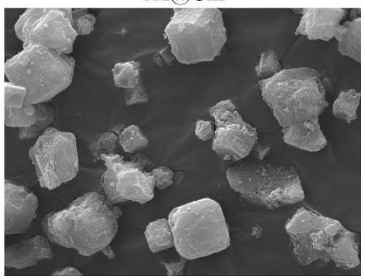
Characterisation - XRD and SEM

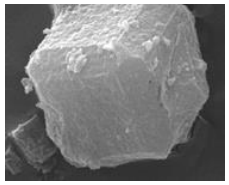


5A

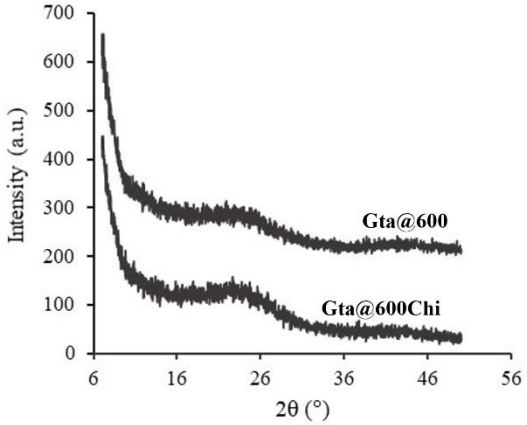


5A@Chi

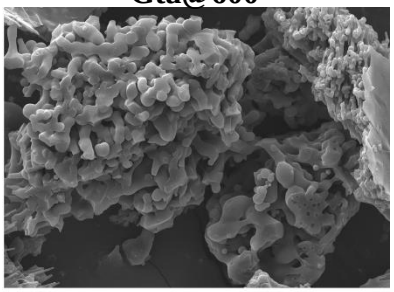




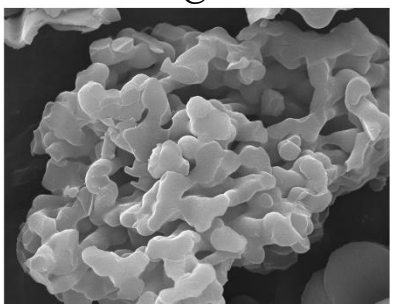
The presence of chitosan can be observed on the material surface.



Gta@600

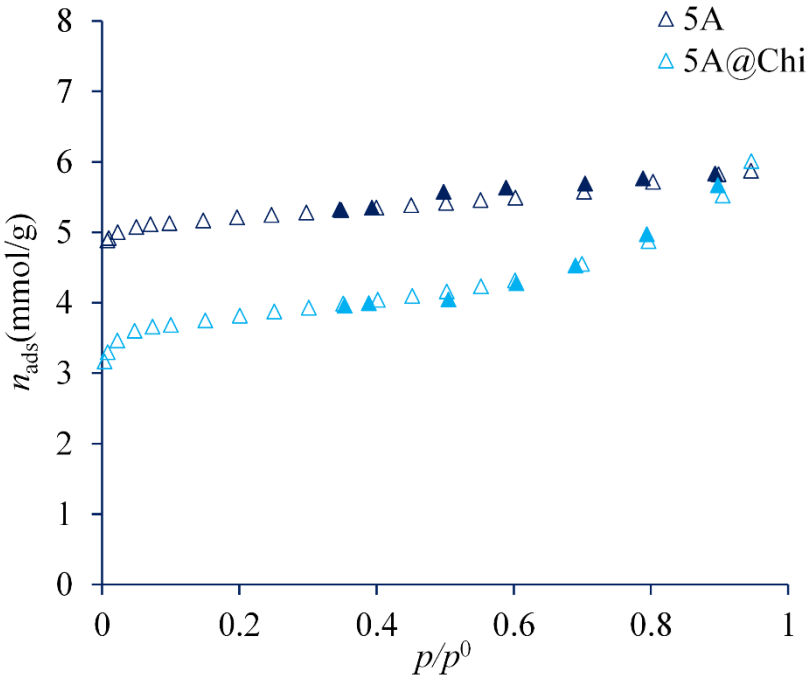


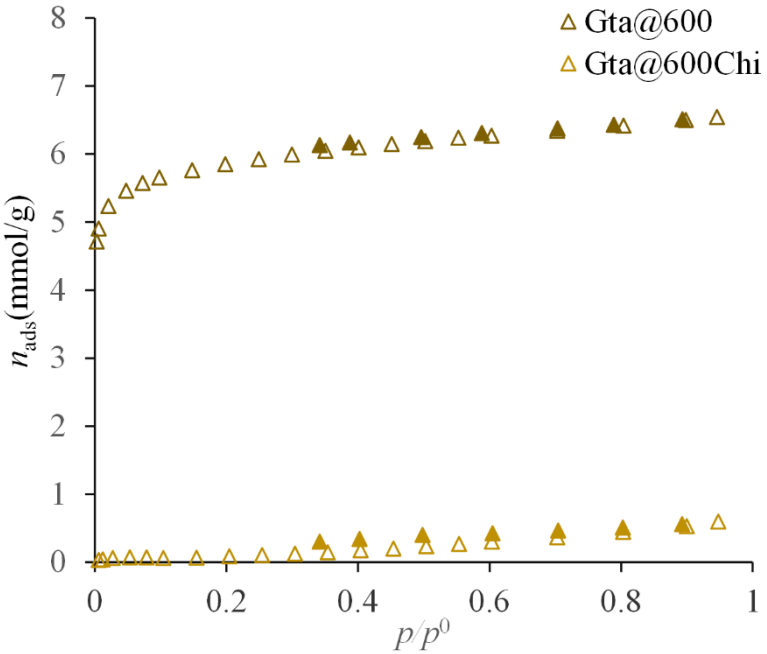
Gta@600Chi



The presence of chitosan is not so noticeable in the SEM images as for zeolites biocomposites.

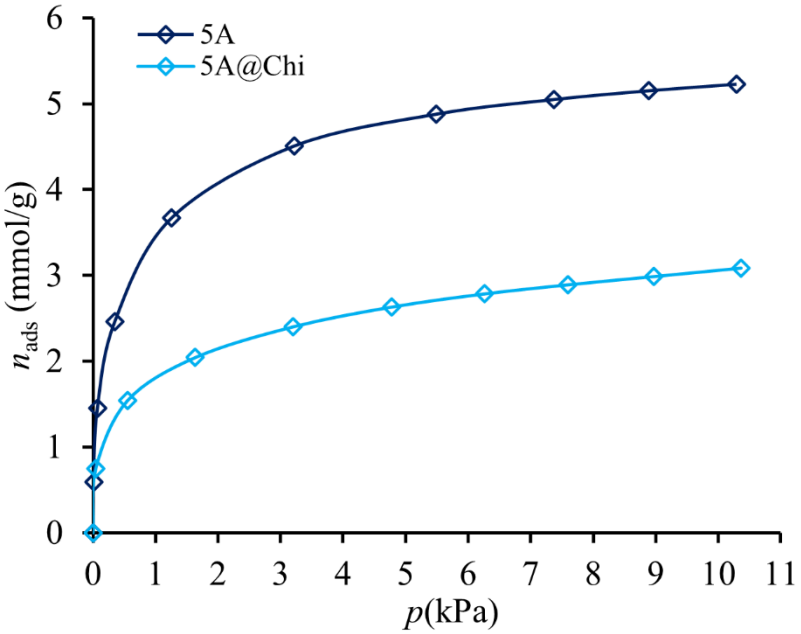
Characterisation - N_2 isotherms

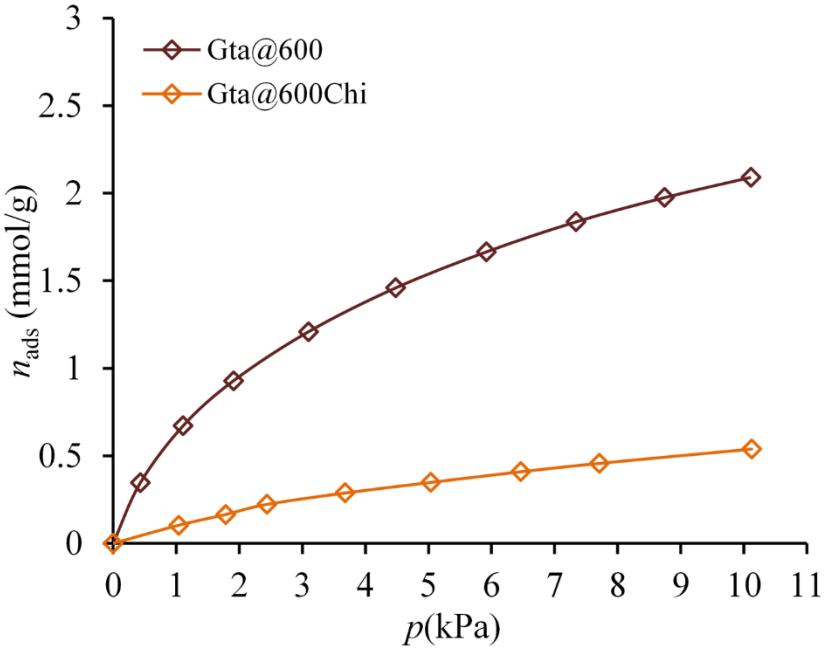




	4A	4A@Chi	5A	5A@Chi	Gta@600	Gta@600Chi
A_{BET} (m^2/g)	363	48	409	301	466	< 5

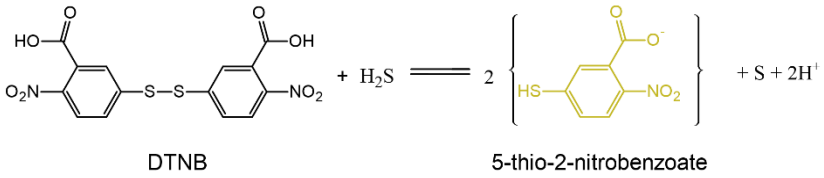
H_2S Adsorption



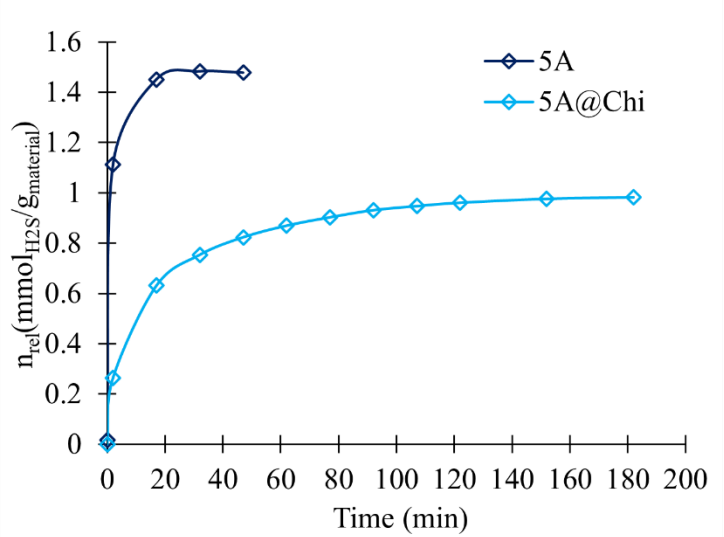


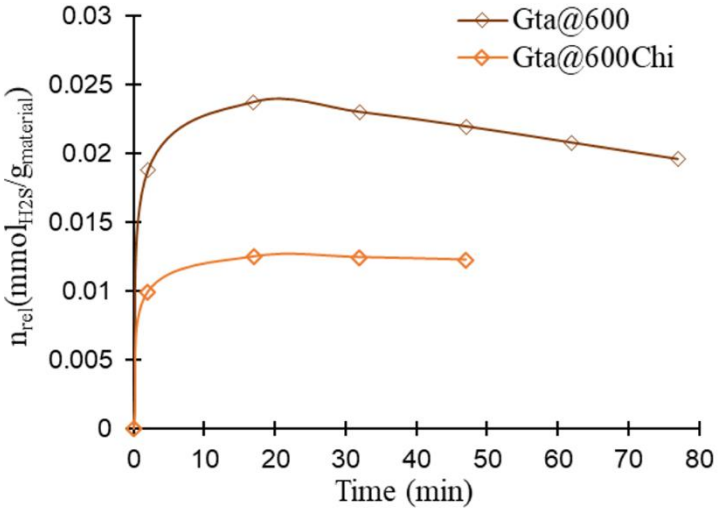
	4A	4A@Chi	5A	5A@Chi	Gta@600	Gta@600Chi
$H_2S_{max\_adsorbed}$ ($mmol_{H2S}/g_{material}$)	3.1	0.1	5.2	3.1	2.1	0.5

H_2S release in aqueous solution at pH 7



DTNB 5-thio-2-nitrobenzoate

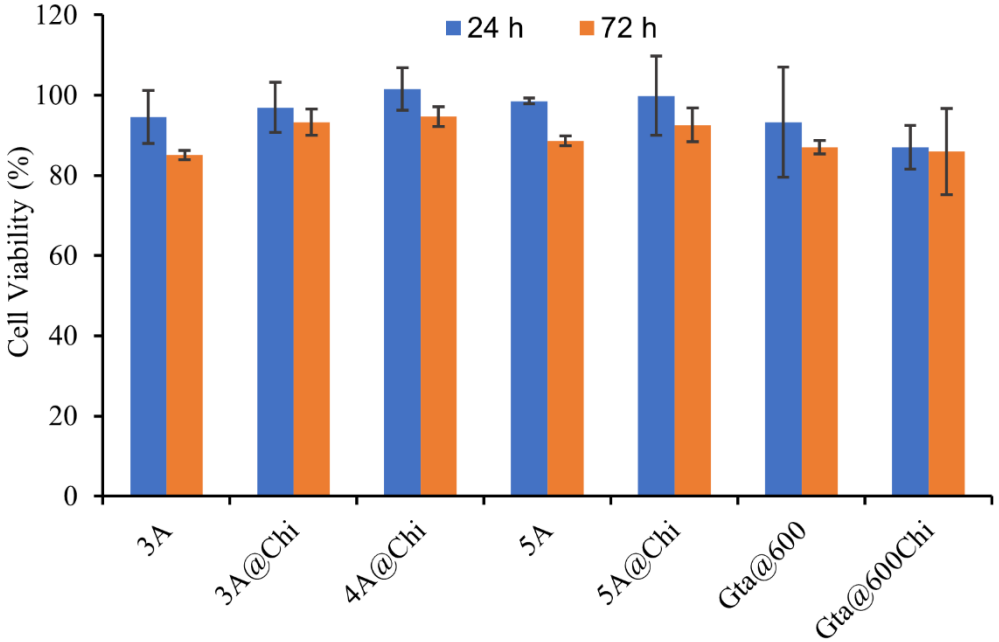




	3A	3A@Chi	4A	4A@Chi	5A	5A@Chi	Gta@600	Gta@600Chi
$H_2S_{released}$ (mmol$_{H2S}$/g$_{material}$)	1.6	0.02	1.35	0.03	1.48	0.98	0.02	0.012
t_{max} (min)	17	17	17	17	17	120	17	17

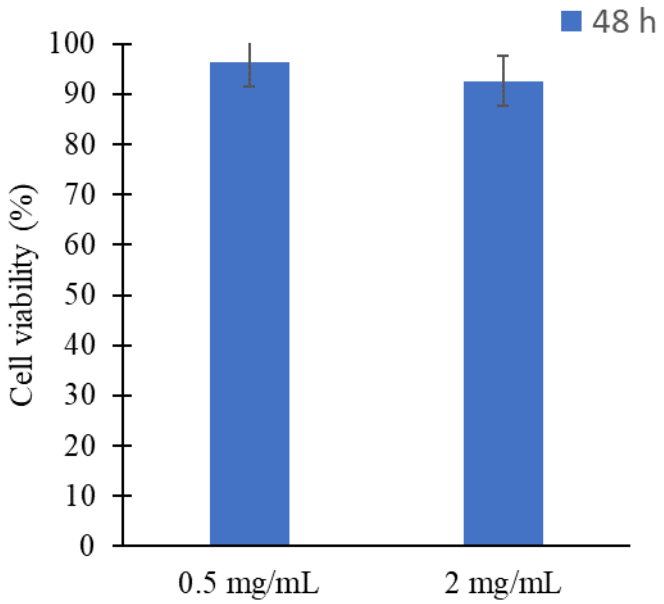
Cytotoxicity studies

HeLa viability in the presence of unloaded materials (450 μg/mL).
Each bar represents an average (of 3 independent experiments each one with 8 replicates) ± SD.



No toxicity was observed for any of the materials

HeLa viability in the presence of H_2S loaded material (5A@Chi - 0.5 mg/mL and 2.0 mg/mL). Each bar represents an average (of 3 independent experiments each one with 2 replicates) ± SD.



No toxicity was observed for 5A@Chi H_2S loaded material

Conclusions

- The modification of the materials with chitosan was successfully achieved;
- The 5A zeolite showed the higher adsorption capacity for H_2S;
- The H_2S release studies in aqueous solutions showed that the composite 5A@Chi had the longest release time (120 min);
- Cytotoxicity studies showed all the materials are no toxic to HeLa cells;
- H_2S loaded 5A@Chi also showed no cytotoxicity to HeLa cells;
- 5A@Chi are the most promising material for further studies.

Acknowledgments

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