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Microfluidic Fabrication of Graphene Oxide – Enriched Alginate Nanocomposite Hydrogels for Enhanced Porous Structure and Antibacterial Wound Dressing

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INTRODUCTION & AIM

A major challenge

- **Infection control * Skin adaptation *Biomechanical compatibility * Structural morphology for wound dressing.**

Aim: **Exploring microfluidic preparation of hierarchically porous graphene oxide(GO)-enriched nanocomposite hydrogels for antibacterial resistant, skin adaptable, mechanically strength wound dressing from bubbles by using a T-shaped microfluidics junction (TMJ) device technique.**

Objectives: **Preparation of GO-enriched nanocomposite hydrogels via a TMJ device technique and compare the once achieved with a conventional method.**

Preparation of suitable solution for GO-enriched nanocomposite hydrogel production by a TMJ device technique, and characterization of their solution features (surface tension , contact angle, viscosity and density)

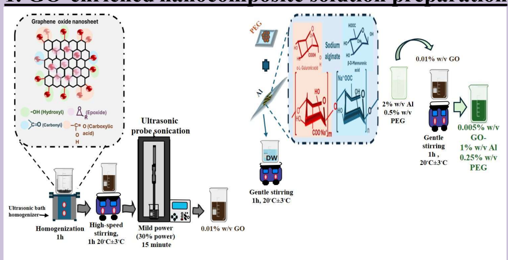
Unveiling of structural, chemical, and mechanical abilities of the GO-enriched nanocomposite hydrogels achived by both routes.

Assesment of water uptake characteristics of the GO-enriched nanocomposite hydrogels achieved by both routes

Anti-bacterial resistance performance of the GO-enriched nanocomposite hydrogels achieved by both routes.

METHOD

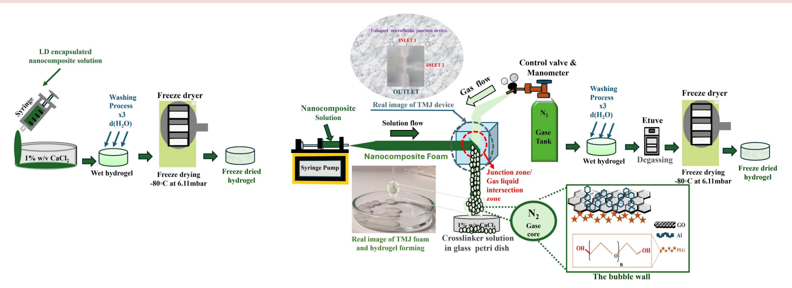
1. GO-enriched nanocomposite solution preparation



In this experimental work (see above), firstly graphene oxide (GO) nanosheets was homogenously distributed in a 100 mL dionized water solution. Secondly, 2% w/v Alginate solution was prepared in a 10mL distilled water, then GO nanosheets solution was mixed together with 1:1 ratio of Alginate:GO nanosheets in a 10 mL beaker then left them stirring for an hour at room temperature environment to incorporation of GO nanosheets solution into the Alginate solution. All the solutions prepared were exaamined with Surface tension, viscosity, contact angle and density to investigate whether they are suitable to use in TMJ device method.

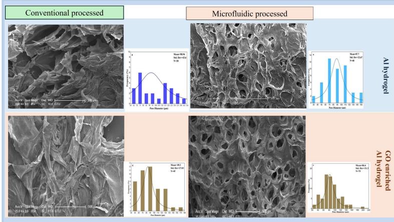
2. GO-enriched nanocomposite hydrogel production by using a TMJ or conventional methods

In this step, the prepared GO-enriched alginate nanocomposite solutions were transformed to hydrogel form by cross-linking them in a 1% w/v CaCI2-distilled water solution via two different waty. Through the route 1 (see above in figure a), the conventional hydrogel preparation method was applied. In this method, the prepared solution in a 10 mL syringe was dropped into a crosslinking solution slowly for 30 minutes. Alternatively, the second route (seen above in figure b) which is consisting of the TMJ device method was processed to fabricate hydrogel formation. During this process, the prepared solution in a 10 mL syringe was inserted into the junction area of the TMJ device with a help of syringe pum as the nitrogen inert gas in a gas tank was filled in the same junction area to come together to generate bubbles at the top edge point of exit channel, then moved thoughout the exit channel to make cluster of bubbles then gently dropped down into the cross-linking solution. Then these bubbles left for hydrogel formation before degassing process was applied. Subsequently, these hydrogels were left in a vacuum oven to degass nitrogen gas and replace hierarchally formed porous structures with a water in its own structure.

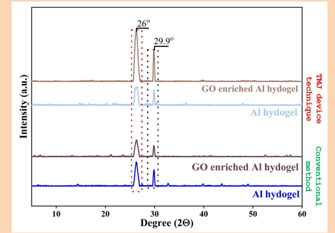


The achieved nanocomposite hydrogel structures with both methods were freze-dried under 6.11mbar pressure at -80ºC for 24 hours to increase stability of porous structure of hydrogels and use them to unveil their structural, chemical, thermal and mechanical characteristics. In addition, these nanocomposite hydrogel structures were examined to determine their water-uptake and antibaterial resistance performance against gram-negative, Esherichia coli (E.coli) and gram-positive Staphlococcus aureus (S.auraus) bacteria.

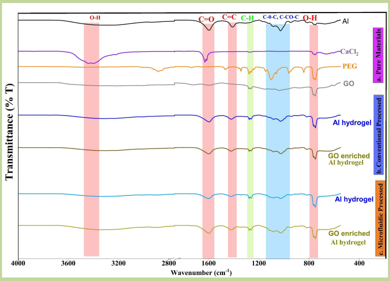
RESULTS & DISCUSSION



SEM captures (see above) of the achieved nanocomposite hydrogel structures presented a better hierarchial porous structures formation on the hydrogels achieved by the TMJ device method. These pictures confirm that TMJ device method manipulated pore morphology of GO-Alginate hydrogels and only Alginate hydrogels. Average pore diameter of the both hydrogels achieved by the TMJ device technique are about 80-90µm with standard deviation of 11µm.

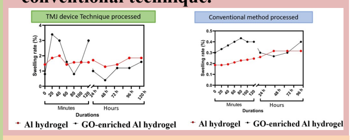


XRD results (see above) showed cystal structures of the nanocomposite hydrogels formed. They indicates an addition of GO into Alginate polymers increased a crytalline form of the Alginate hydrogels.

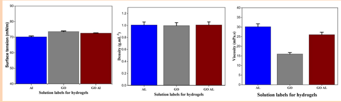


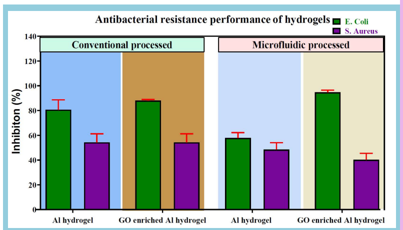
FTIR Spectra (see above) of starting materials, the hydrogels formed via the conventional technique and the hydrogels fabricated by using the TMJ device technique are presented in this graph. This graph represents main functional groups of Alginate, graphene oxide nanosheets and nanocomposite hydrogel structures achieved. It also confirms there is influence of the TMJ device method used on chemical compounds of nanocomposite components.

Results of Water-uptake measurements (see below) showed swelling ratio of the achieved hydrogels for 7 days under PBS solution and 37 ºC environment. This graphs indicated the TMJ device method increased swelling ratio of the nanocomposite hydrogels achieved compared to the ones prepared by the conventional technique.

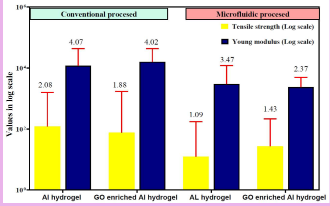


Surface tension, density and viscosity results of the solutions used for two different fabrication routes are presented in these graphs (see below). These graphs presented that GO incorporation into Alginate solution slightly increased viscous behaviour, making suitable.





Antibacterial performance results of the nanocomposite hydrogels achieved by two different routes (see above). A use of TMJ device technique increased S.aureus and E.coli inhibition as only GO inclusion presented a decrease in E.coli inhibition.



Tensile strength and Young modules values (see above) of the nanocomposite hydrogels achieved by two different routes. These coloum graphs presented an increase in young's module and tensile strength values (meaning better mechanical strength) resulted in an addition of GO as a decrease in these values brought about the TMJ device method.

CONCLUSION

- ✓ **The GO-enriched alginate nanocomposite hydrogel wound dressing material with their enhanced porosity, suitable mechanical strength and better antibacterial performance have been conceived using a TMJ device method.**
- ✓ **Both a GO nanosheet enrichment and a use of the TMJ device technique increased antibacterial performance of alginate hydrogel wound dressings.**
- ✓ **For further researches, pain and infection management could overcome with a benefit of these novel contributions for fabricating bioactive wound dressings.**

FUTURE WORK / REFERENCES

- ✓ **References are inserted into the QR code (See scan, rightside) and if you have any questions contact to me via**
- ✓ **berayhan@gtu.edu.tr**