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Investigating the 8CB Liquid Crystal-Insulin Interaction: The Role of the Smectic A Phase in Enhancing Detection Sensitivity

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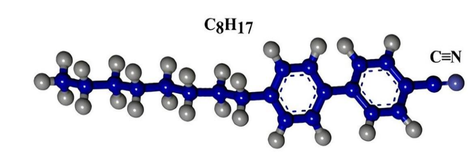
INTRODUCTION & AIM

Liquid crystal (LC) biosensors have emerged as a viable platform for protein detection due to their distinct optical and dielectric features. These biosensors utilize LC's responsiveness to external stimuli, which includes interactions with biomolecules such as proteins. LC's molecular alignment and order are extremely sensitive to changes in their surroundings, allowing for highly sensitive and selective protein identification. This study explores the interaction between **octyl-4-biphenylcarbonitrile (8CB) LC** and **human insulin** to develop a label-free biosensor through a multidisciplinary approach.

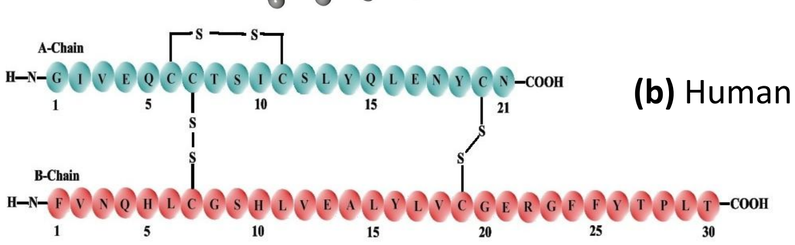
RESEARCH GAP

Despite **8CB**'s promising structural features for enhanced biosensing sensitivity, its application in detecting human insulin (HI) remains unexplored. Investigating 8CB-HI interactions could reveal new insights into leveraging smectic ordering for improved biosensor performance.

MATERIALS

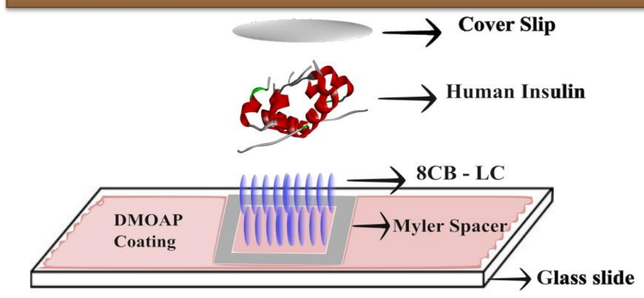


(a) Octyl-4-biphenylcarbonitrile (**8CB**) LC



(b) Human Insulin (Chain A and B)

METHOD OF PREPARATION OF SAMPLES

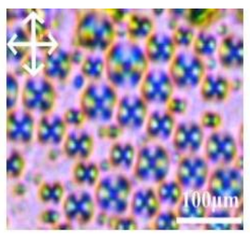


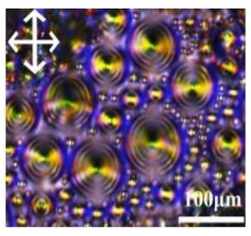
DMOAP: dimethyl octadecyl [3-(trimethoxy silyl) propyl] ammonium chloride – Helps in **homeotropic arrangement of LC**

RESULTS & DISCUSSION

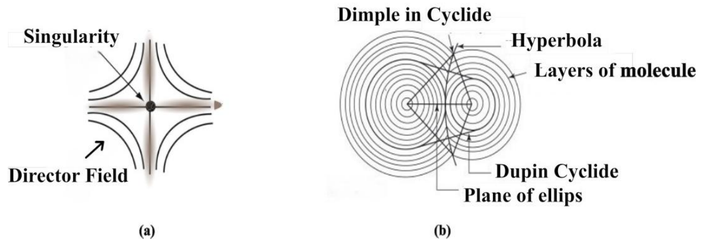
Polarising Optical Microscopy Studies

Radial



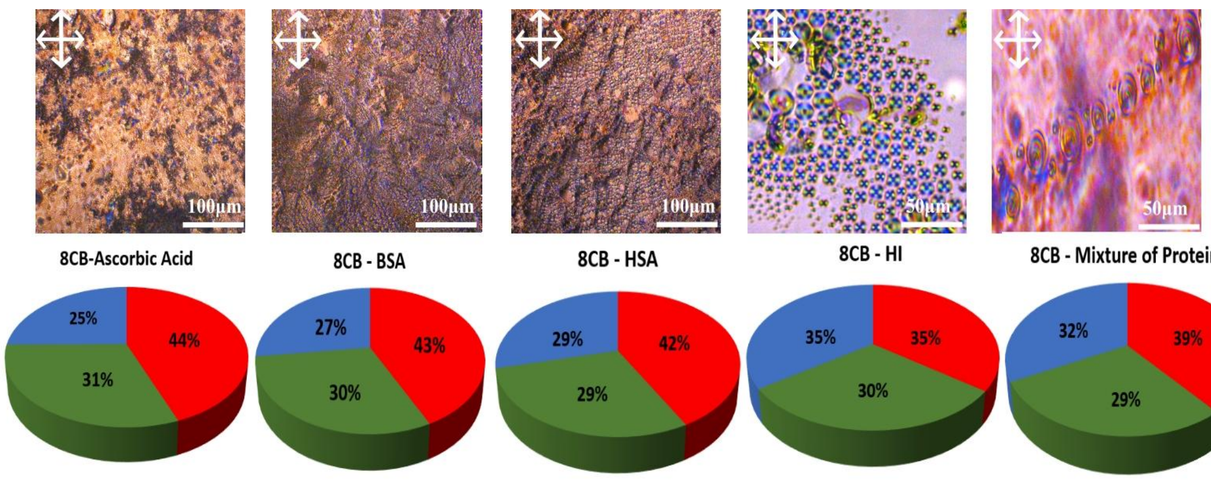


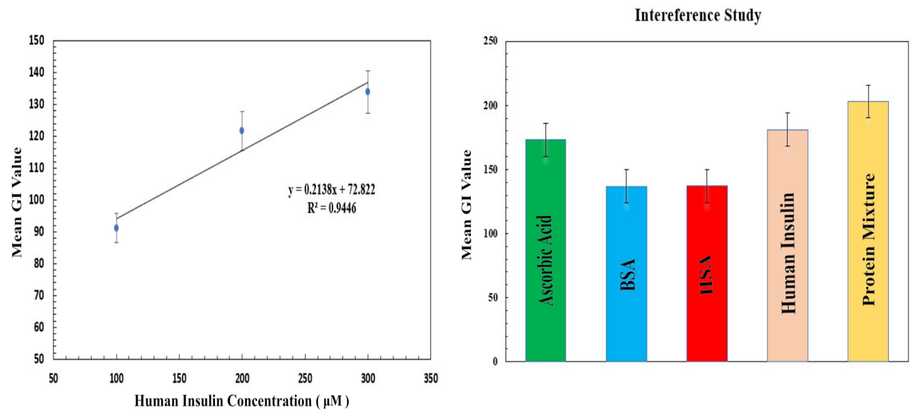
Focal-Conic



POM observations of 8CB interacting with the HI (**20-300 µM**, time-dependent) showed two main textures: **Radial and Focal conic.**

Selectivity, Sensitivity, and Detection Limit

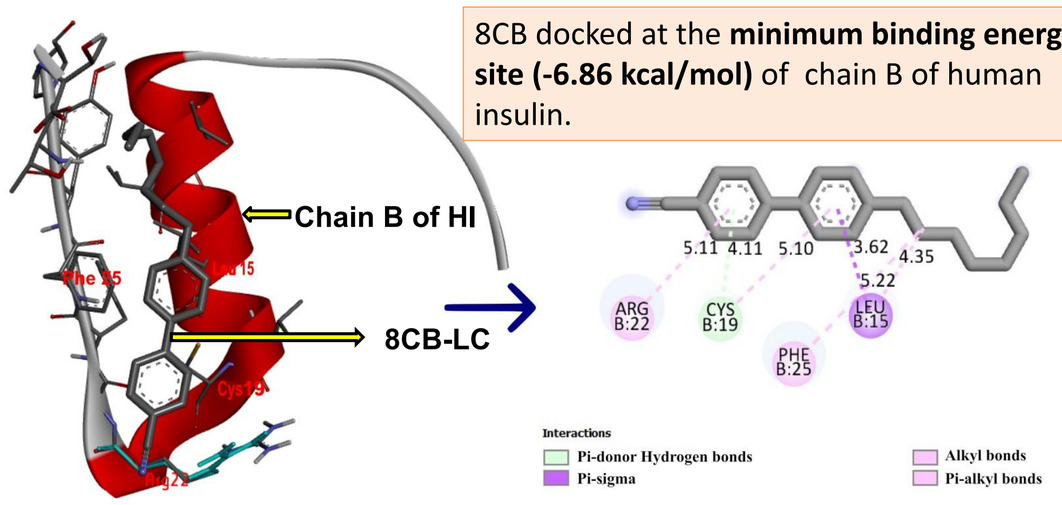




- The **limit of detection of this study** (LOD) was found to be **20 µM**. An **R^2 value of 0.9446** was observed. **Linearity Range: 100 to 300 µM.**
- The **RGB** and **grey index (GI)** studies confirmed the **selectivity of HI** to **8CB-LC**.

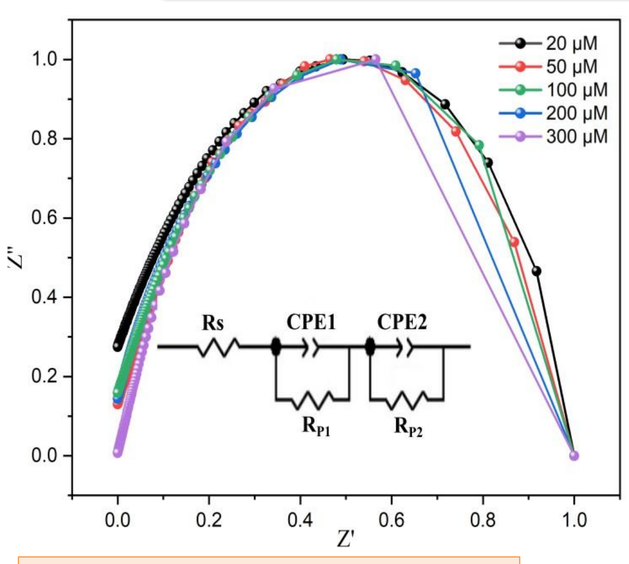
Molecular Docking Studies

8CB docked at the **minimum binding energy site (-6.86 kcal/mol)** of chain B of human insulin.

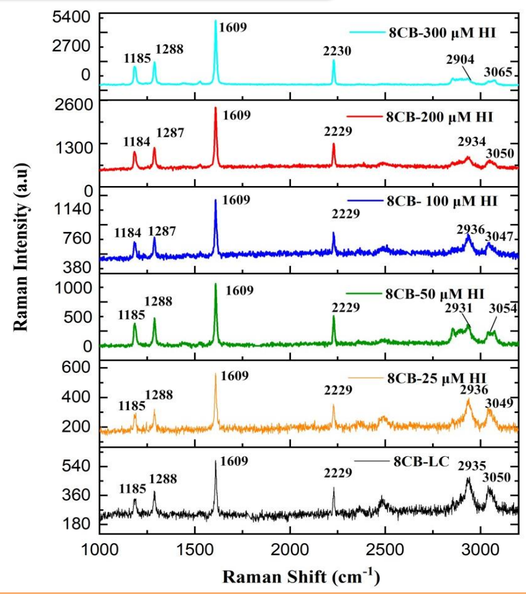


Amino acid residues of HI such as **Arginine, Cysteine, Phenylalanine, and Leucine** forms interactions with 8CB-LC at minimum binding energy site.

Dielectric and Raman Spectroscopy Studies



The **Nyquist plot** of **8CB-HI** shows two overlapping semicircles fitted with an equivalent electrical circuit (EEC) model comprising Rs, Rm, and CPEm elements, confirming **capacitive behavior** ($\alpha > 0.5$).



The major change in the peak positions of 8CB-LC spectra on interacting with HI was observed in the **higher frequency region (alkyl chains)** due to the interaction of **Amide III and Phenylalanine residues, indicating alkyl chains of 8CB are more reactive to HI.**

CONCLUSION AND FUTURE WORK

This study presents the **first comprehensive multi-technique investigation** of **human insulin detection using 8CB liquid crystal**, highlighting the **enhanced sensitivity achieved** when **8CB operates in its smectic A phase** compared to its nematic homologs. This integrative approach paves the way **for label-free**, cost-effective detection of human insulin using liquid crystal-based biosensing platforms.

REFERENCES

1. **A. Satya**, A. Bhattacharjee, **Investigating the 8CB Liquid Crystal-Insulin Interaction: The Role of the Smectic A Phase in Enhancing Detection Sensitivity**, - ***International Journal of Biological Macromolecules***, 2025, https://doi.org/10.1016/j.ijbiomac.2025.148322

2. **A. Satya**, A. Bhattacharjee**, Developing a biosensing prototype utilizing a 7CB liquid crystal for human insulin detection**, - ***Physical Chemistry Chemical Physics***, 2024. https://doi.org/10.1039/c9sm01424a

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