Military University of Technology Warsaw, Poland

Faculty of Advanced Technologies and Chemistry

The 4th Polish-Slovenian International Seminar on Soft Matter

26th - 27th January 2026

Self-assembled benzo[b]thiophene liquid crystals with designed dielectric properties for GHz applications

Agnieszka Mieczkowska, Jakub Herman, Natan Rychłowicz, Monika Zając, Piotr Harmata

Motivation of research

The development of self-organizing materials follows two application-driven streams: one in the visible range, originating from LCD technology, and another beyond visible light. Recently, liquid crystals have attracted significant interest in the microwave range, particularly 10–60 GHz, which is widely used in wireless communications, including satellite links, radar, point-to-point systems, and WLANs. Operation in this range requires specially designed liquid crystal cells, with optimized layer thickness, materials, and fabrication techniques to minimize losses. The key parameters defining liquid crystal suitability are tunability τ and dielectric loss tanδ measured in the GHz range.

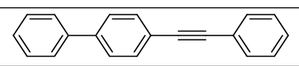
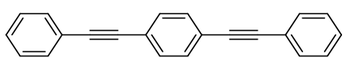
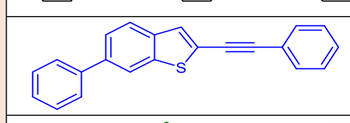
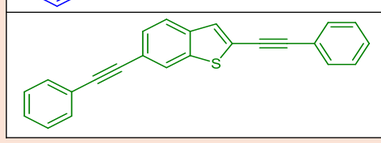
where: $\tau = \frac{\varepsilon_{\parallel} - \varepsilon_{\perp}}{\varepsilon_{\parallel}}$ $tan\delta_{\varepsilon} = \frac{\varepsilon_{\parallel}'' - \varepsilon_{\perp}''}{\varepsilon_{\parallel}' - \varepsilon_{\perp}'}$

$\varepsilon_{\parallel}$ - the electric permittivity measured paralel to the optical axis of the molecule

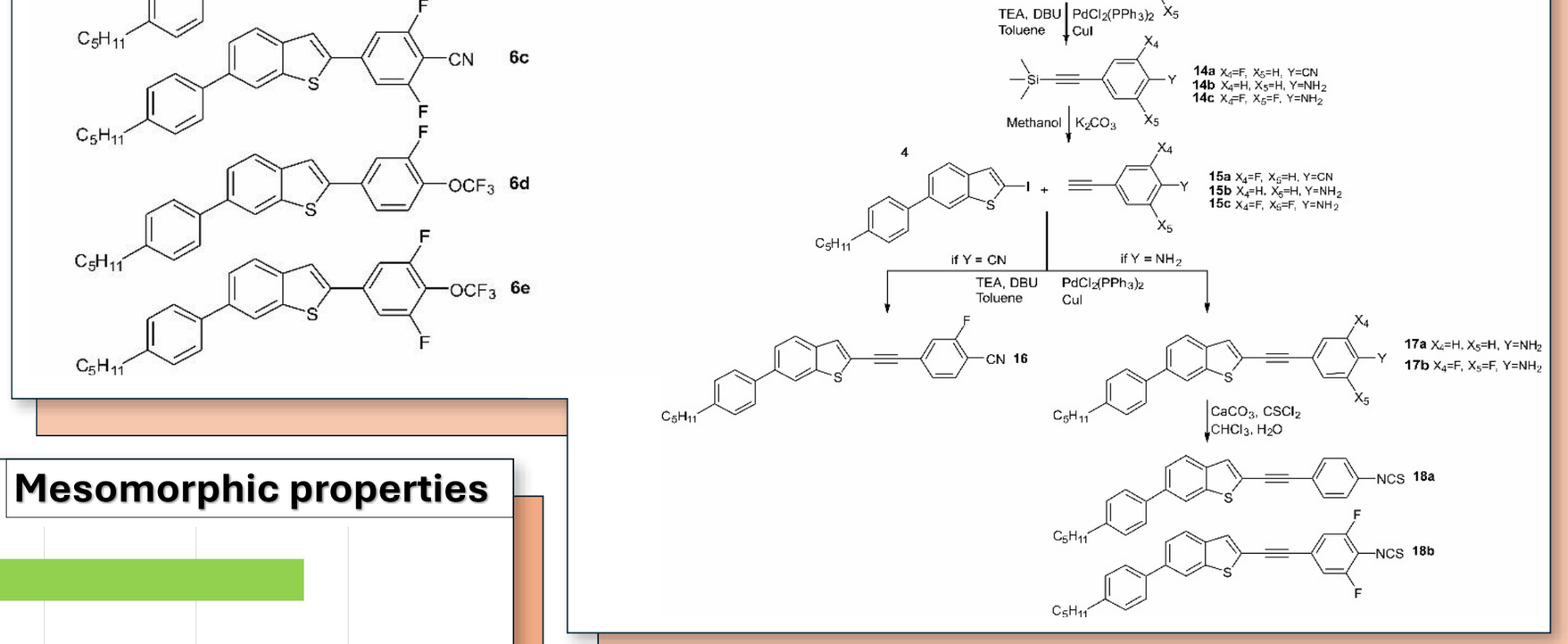
$\varepsilon_{\perp}$ - the electric permittivity measured perpendicular to the optical axis of the molecule

ε' - the real part of the electric permittivity

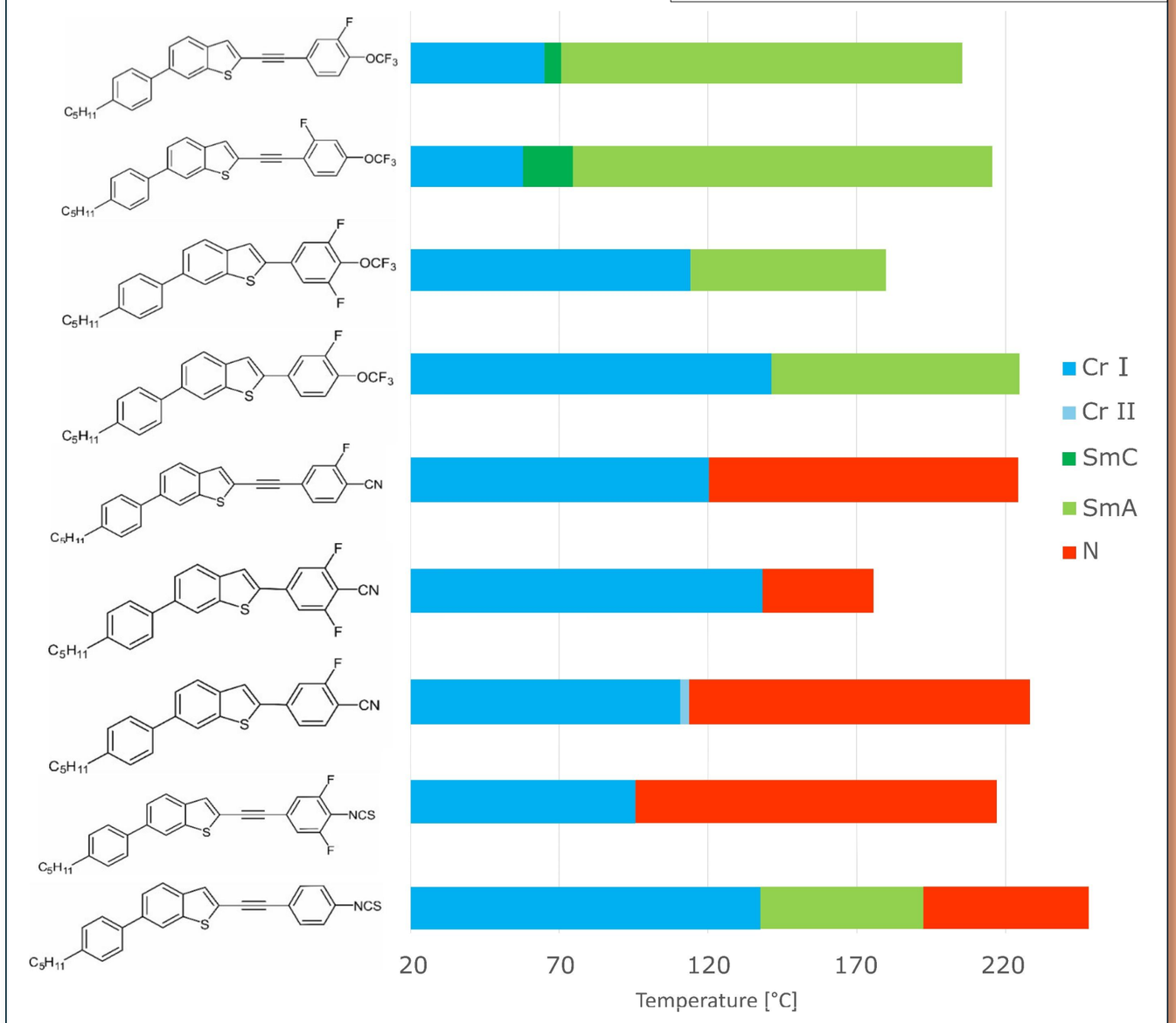
ε'' - the imaginary part of the electric permittivity

Core structure	Polarizability anisotropy Δα = [au]
	354
	528
	463
	642

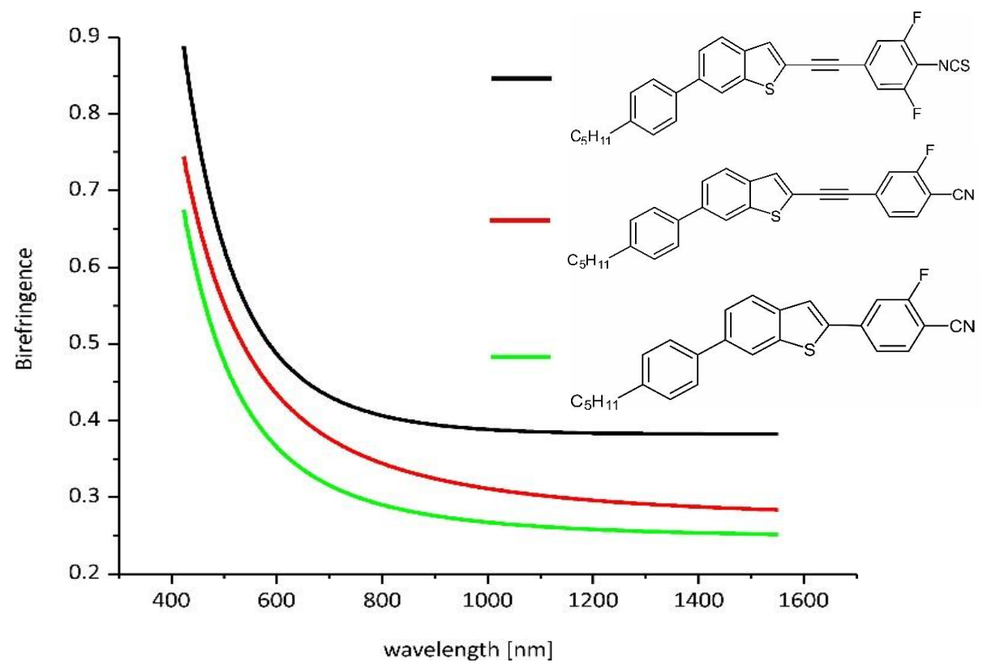
Synthesis



Mesomorphic properties



Optical properties



Compound	Δn		
	443nm	636nm	1550nm
6b	0.6057	0.3431	0.2516
16	0.6788	0.4091	0.2834
18b	0.7946	0.4612	0.3825

Conclusions

- Liquid crystal compounds based on benzo[b]thiophene cores show strong potential for microwave (GHz) applications, as their molecular design enhances polarizability and leads to increased birefringence, particularly when unconventional rigid cores are employed.
- The most promising materials are acetylene-linked benzo[b]thiophene derivatives with polar terminal groups, which exhibit the highest birefringence and are therefore well suited for GHz-range applications.

References:

1. A. Mieczkowska, J. Herman, N. Rychłowicz, M. Zając, P. Harmata - New self-organised benzo[b]thiophene-based materials for GHz applications. Liquid Crystals, 2024, 51(7), 1256–1269.
2. Manabe A. Liquid crystals for microwave applications. 2013 7th European Conference on Antennas and Propagation, EuCAP 2013. 2013 03/01;8642.

Acknowledgments:

The research was supported by the MUT Grant UGB 22-026

agnieszka.mieczkowska@student.wat.edu.pl

Wojskowa Akademia Techniczna
im. Jarosława Dąbrowskiego
ul. gen. S. Kaliskiego 2
00-908 Warszawa
www.wojsko-polskie.pl/wat