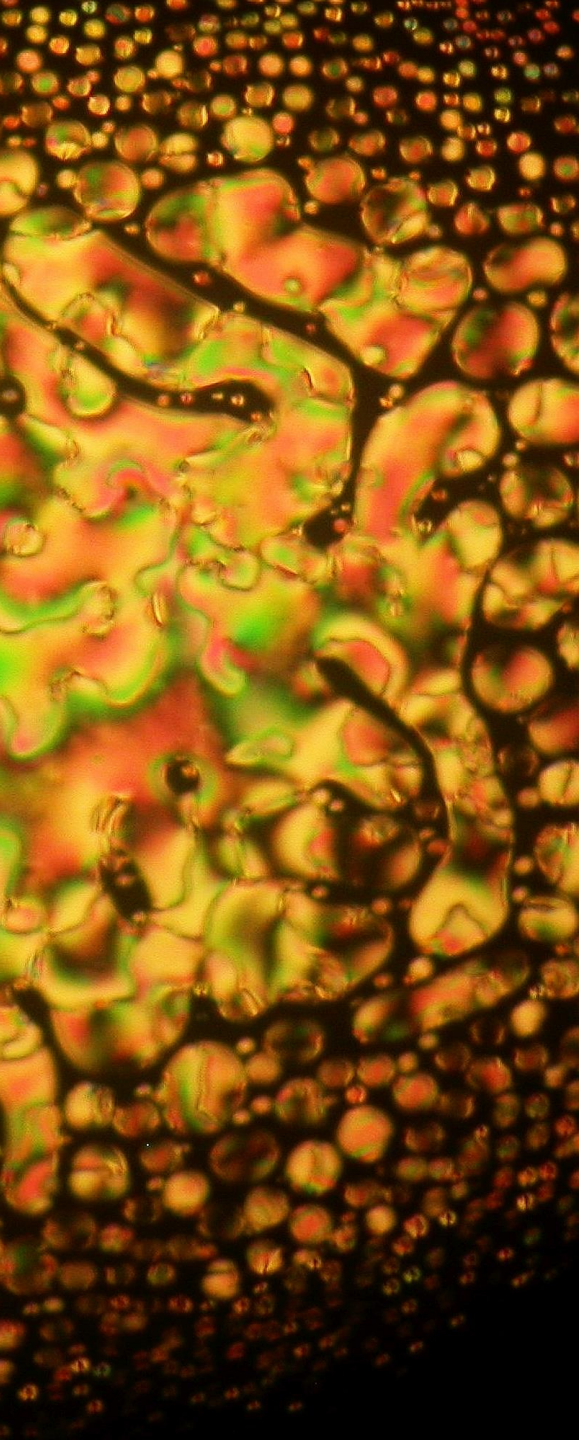


Liquid Crystals: soft matter with enthralling properties

Natalia Podoliak



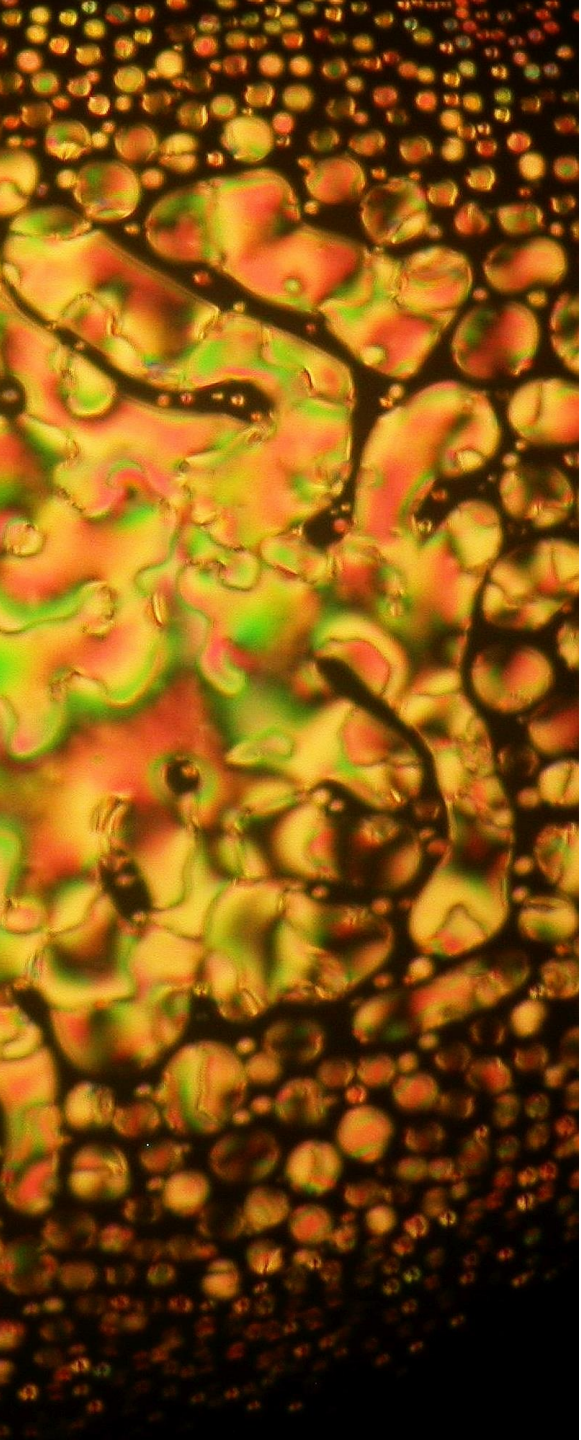
Liquid Crystals

discovery

1888 - F. Reinitzer,
Austrian botanist,
German technical
university in Prague



Husova 5, Prague 1



Liquid Crystals

discovery

1888 - F. Reinitzer,
Austrian botanist,
German technical
university in Prague



V této budově bývalé
Německé university v Praze
objevil v roce 1888
první kapalný krystal

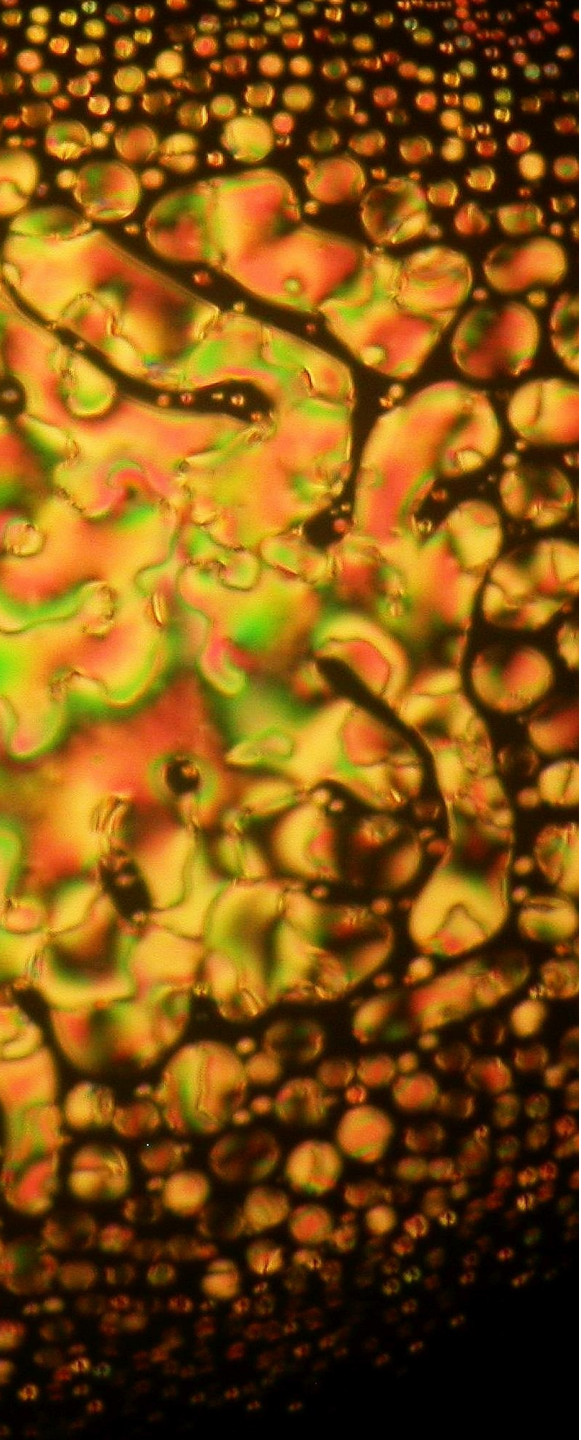
**Prof. Friedrich
Reinitzer**

(*25. 2. 1857, Praha – †16. 2. 1927, Graz)

hat in diesem Gebäude
der Deutschen Universität in
Prag im Jahre 1888 den ersten
flüssigen Kristall erfunden

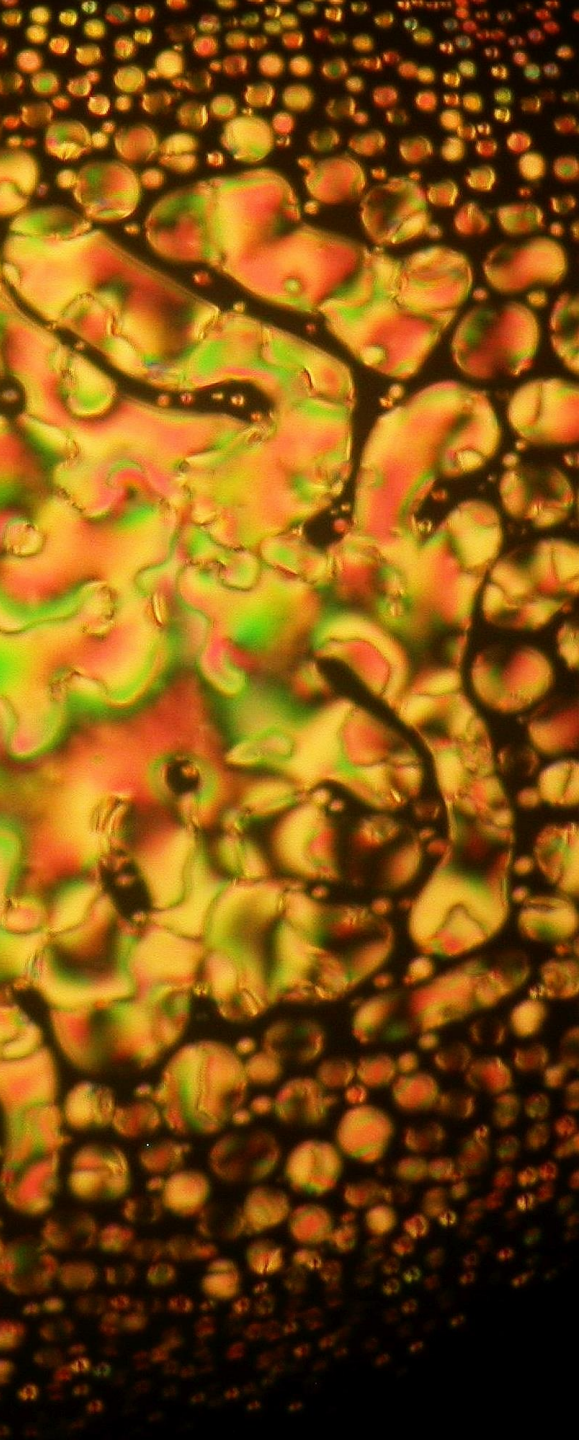


Husova 5, Prague 1



Liquid Crystals

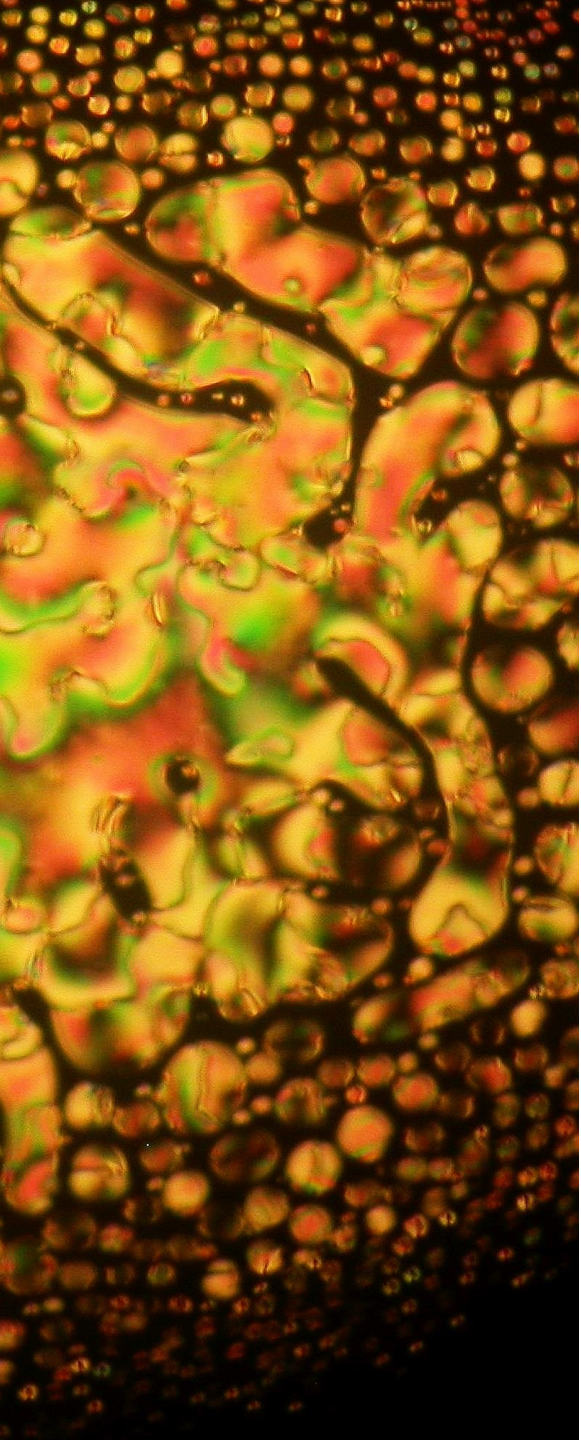
soft matter



Liquid Crystals

soft matter that combines
anisotropy of crystals

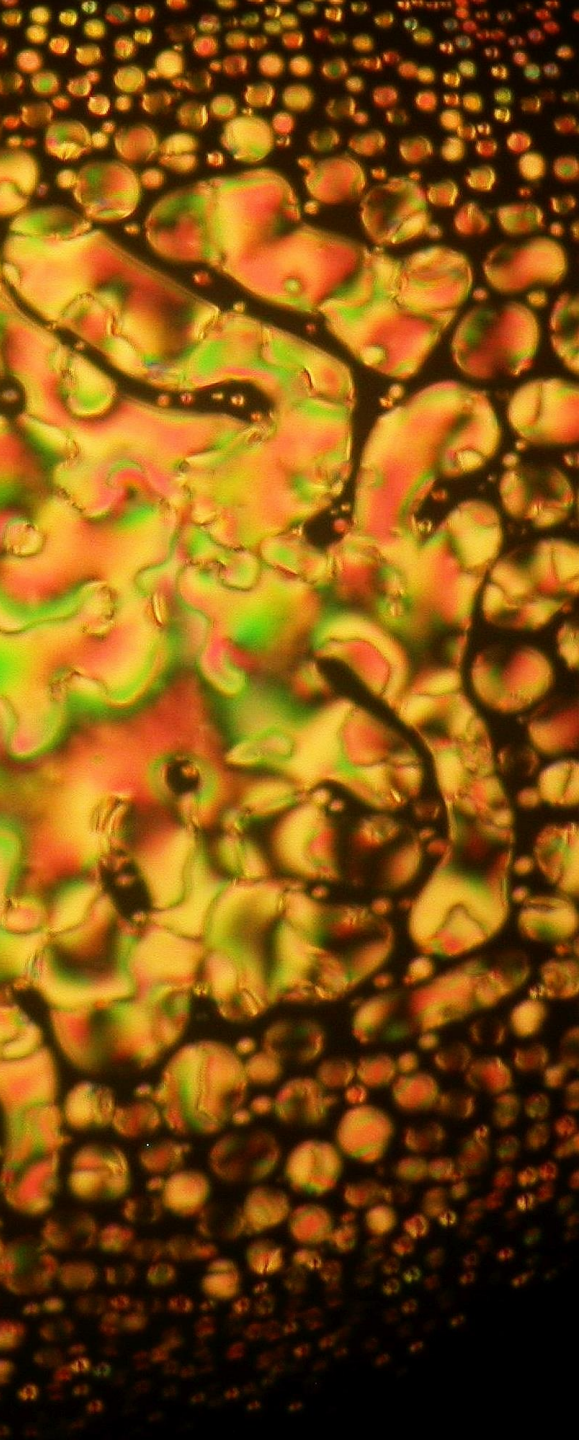




Liquid Crystals

soft matter that combines
anisotropy of **crystals** with fluidity of **liquids**





Liquid Crystals

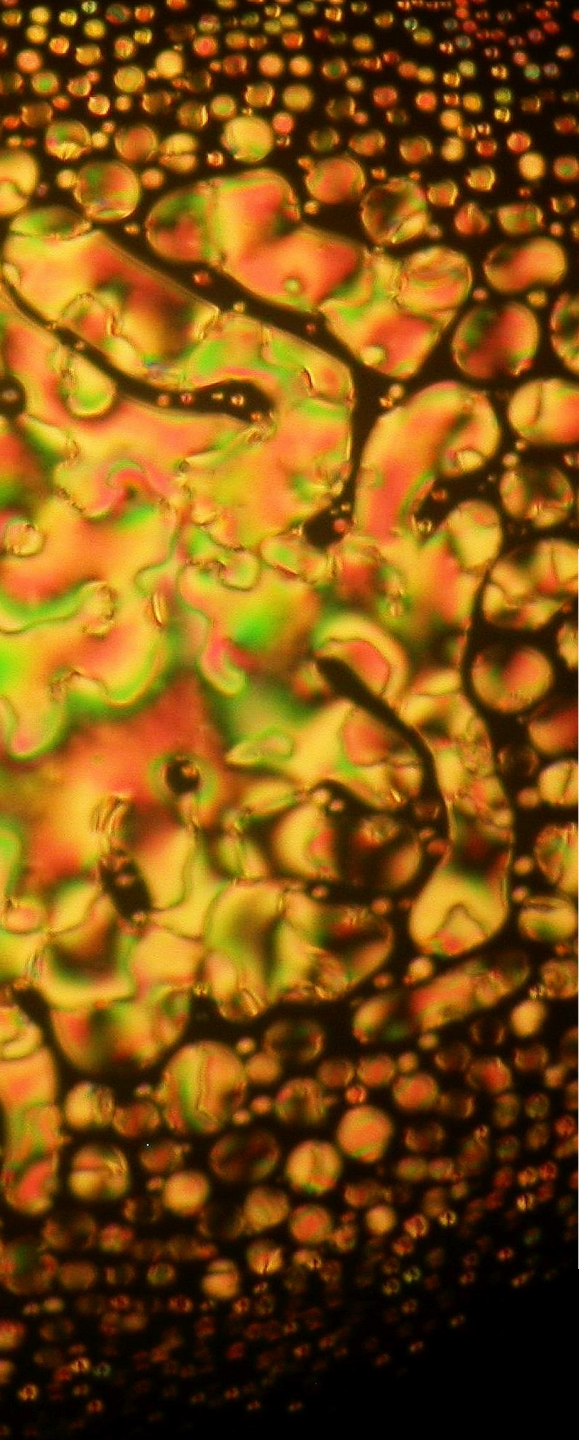
technological applications

Liquid Crystals

technological applications

Monitors





Liquid Crystals

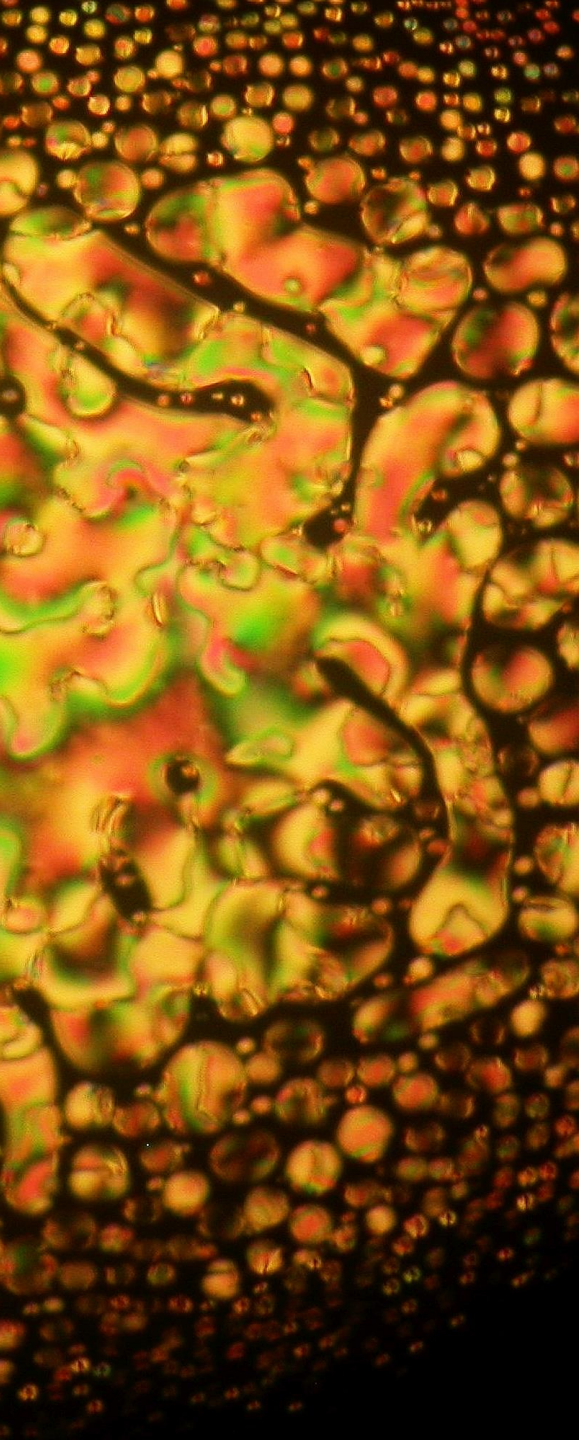
technological applications

Monitors



Medical
applications





Liquid Crystals

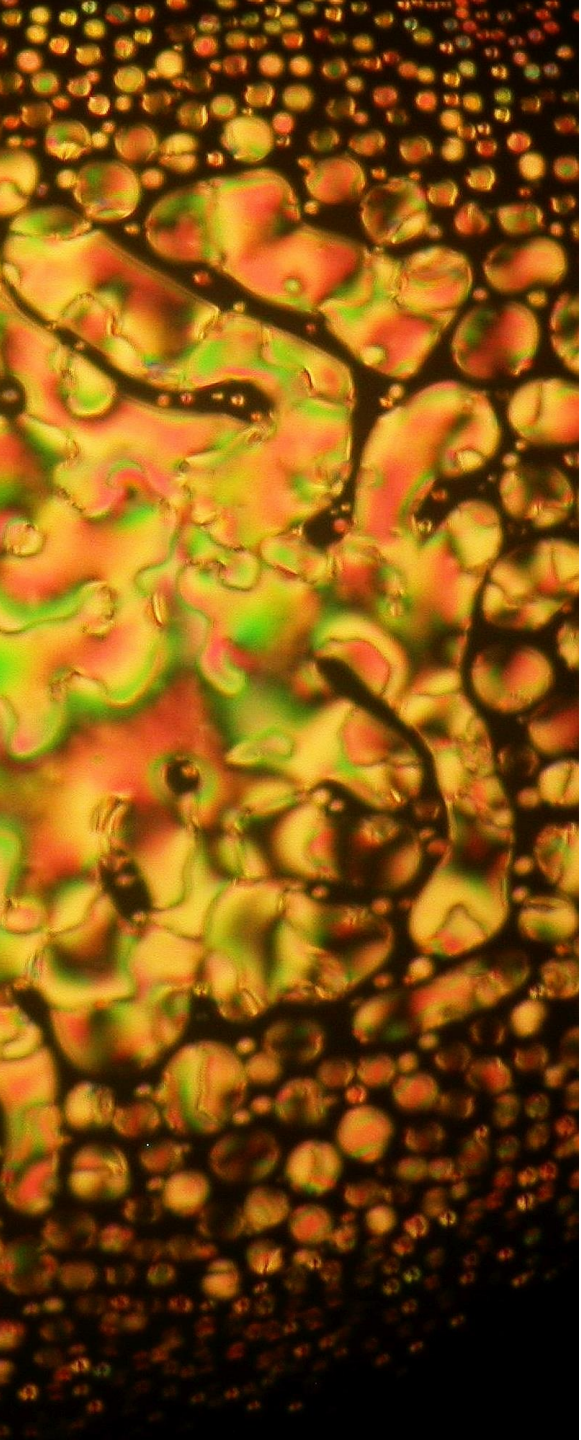
technological applications

Monitors



Private
Medical windows





Liquid Crystals

technological applications

Monitors



Private
Medical windows



Liquid Crystals

technological applications

Monitors

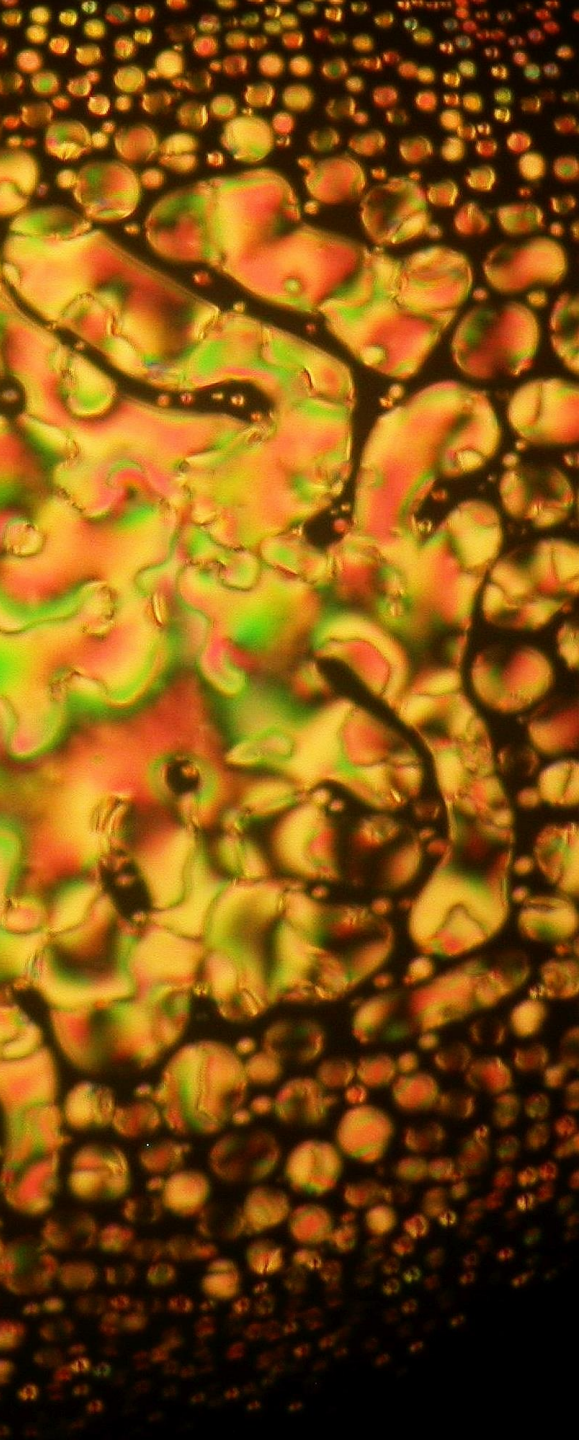


Medical applications



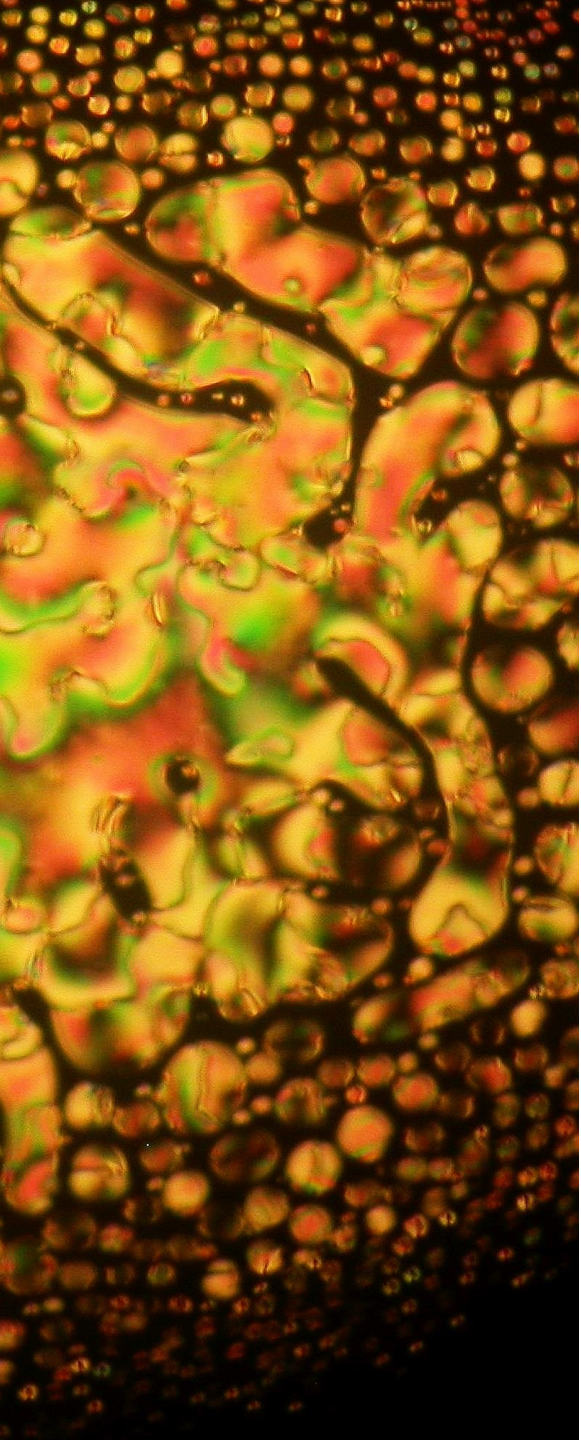
Private windows





Liquid Crystals

material anisotropy – through the molecular anisotropy

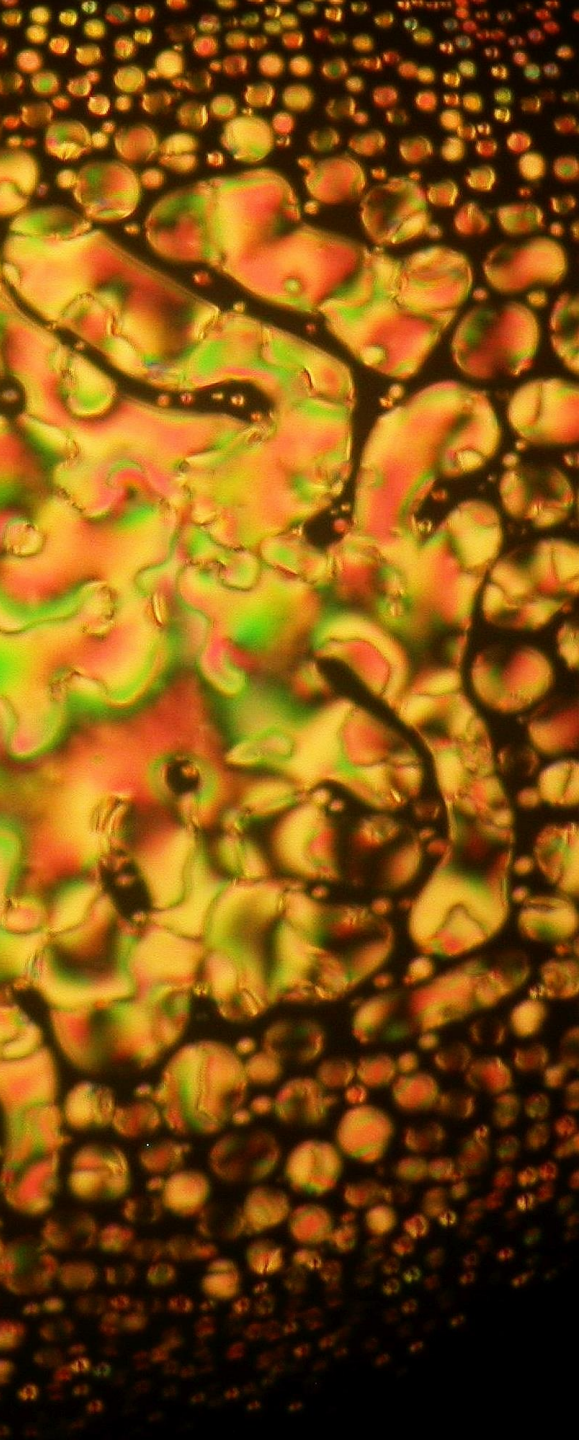


Liquid Crystals

material anisotropy – through the molecular anisotropy

rod-like





Liquid Crystals

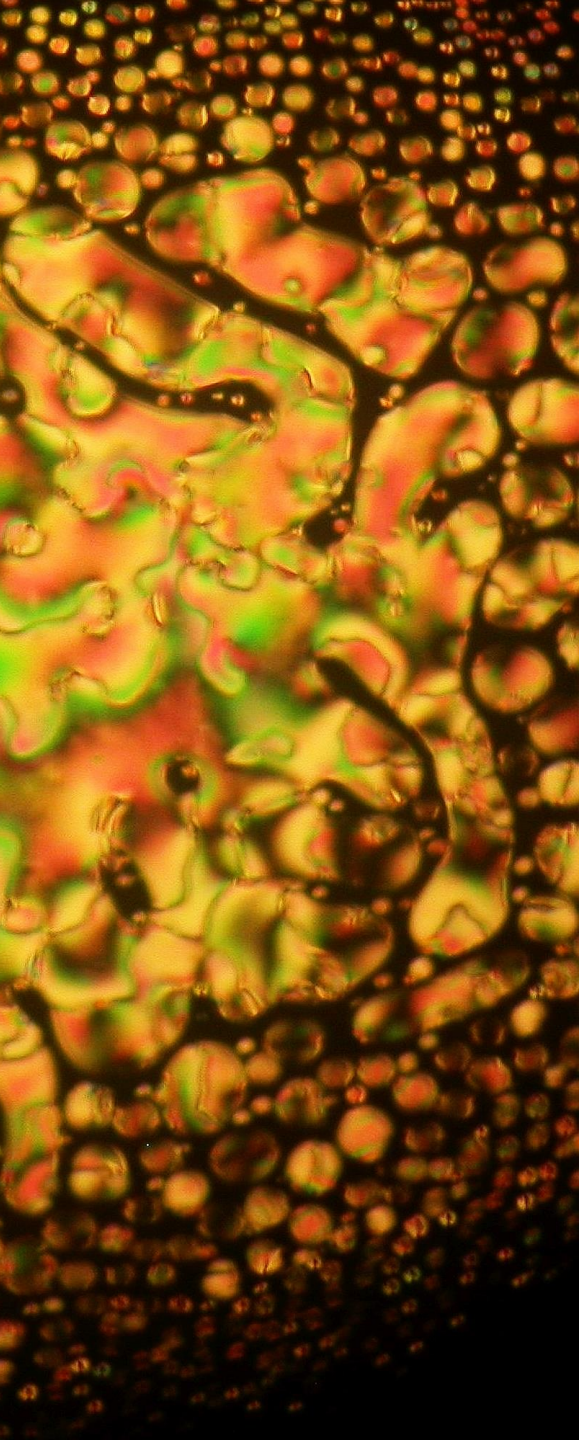
material anisotropy – through the molecular anisotropy

rod-like



disc-like





Liquid Crystals

material anisotropy – through the molecular anisotropy

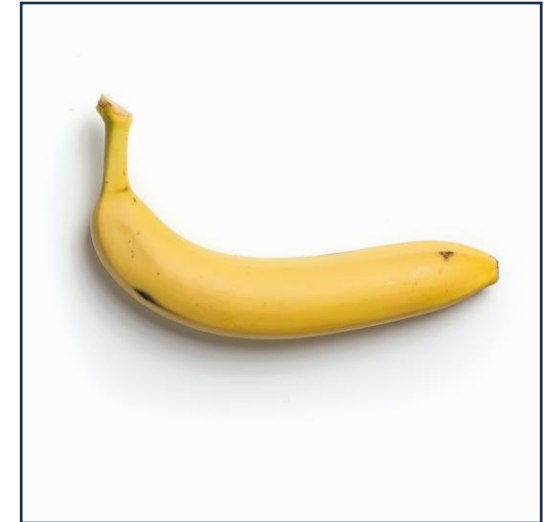
rod-like

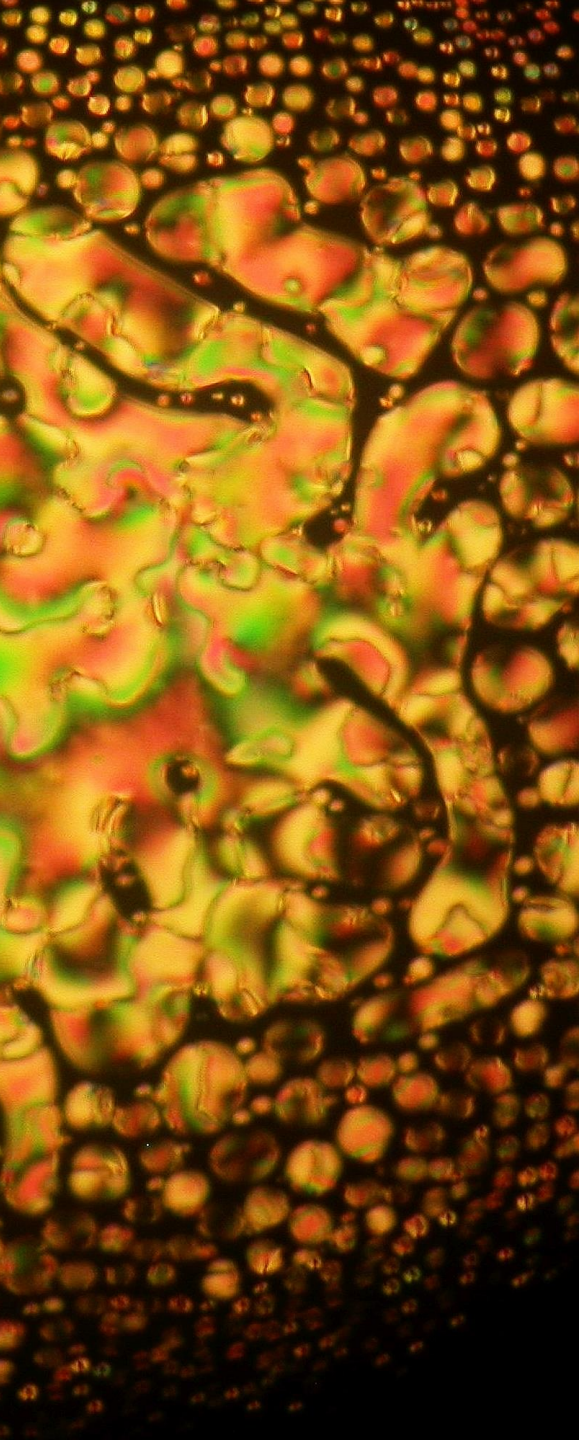


disc-like



banana-shape

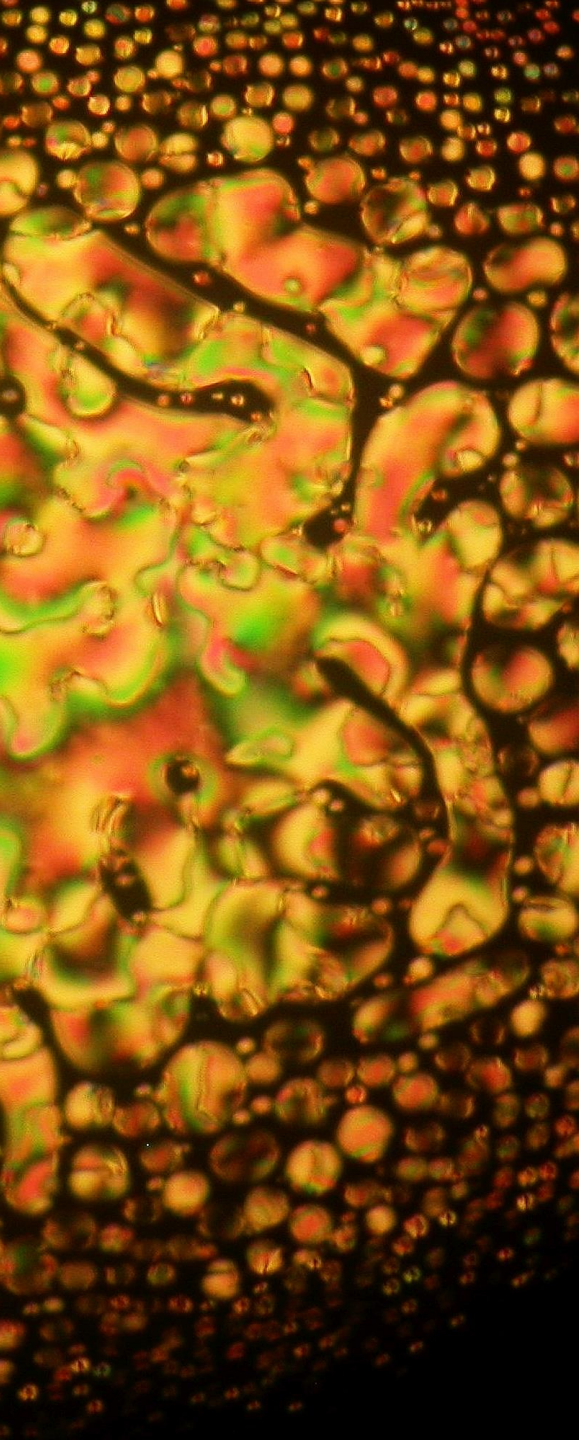




Liquid Crystals:

Thermotropic

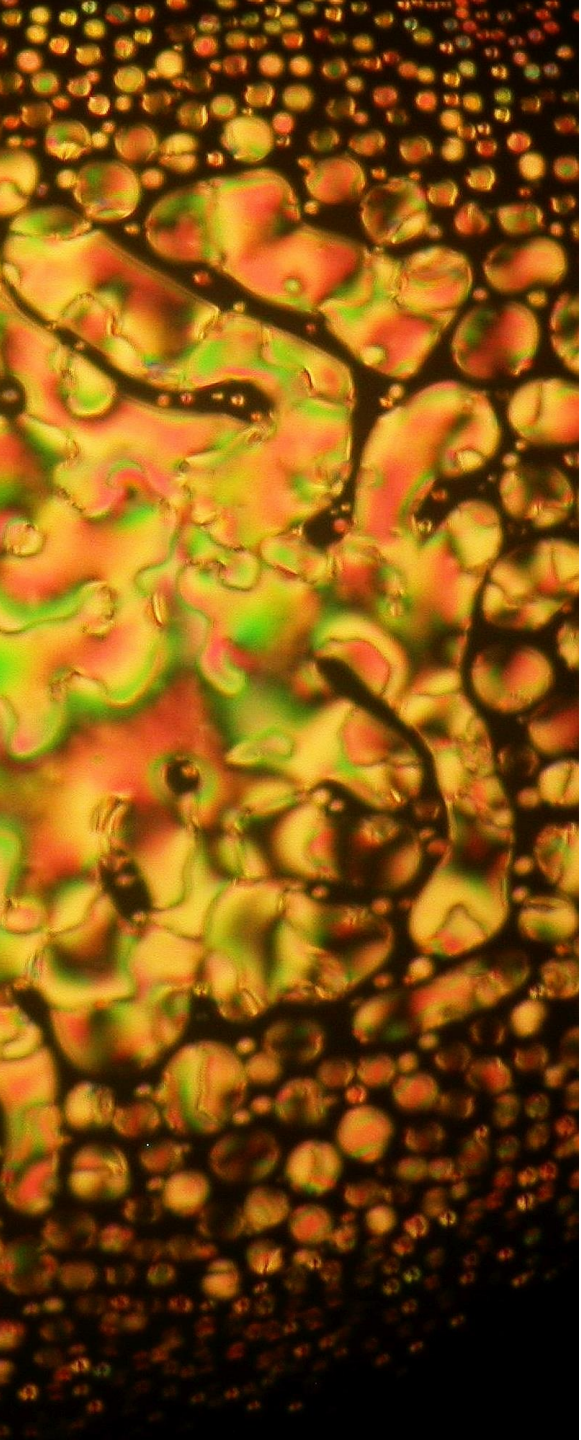
Lyotropic



Liquid Crystals:

Thermotropic – properties depend on **temperature**

Lyotropic

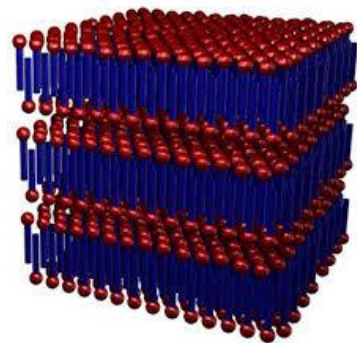


Liquid Crystals:

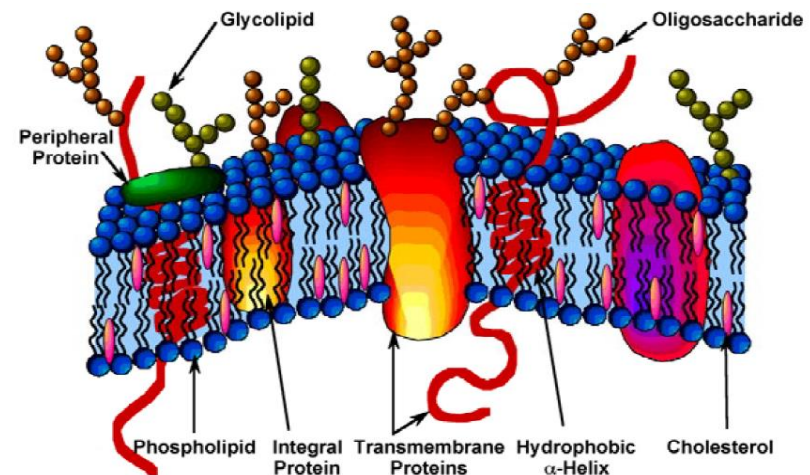
Thermotropic – properties depend on **temperature**

Lyotropic – properties depend on **concentration**

- Formed by amphiphilic molecules – hydrophobic tail(s) + hydrophilic head
- Soaps, cell membranes, various biomolecules (DNA)



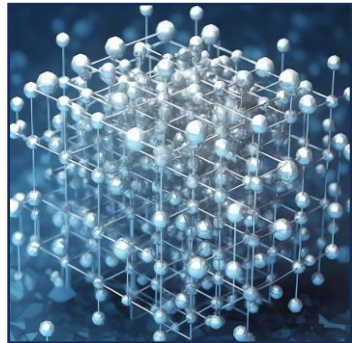
Lamellar mesophase



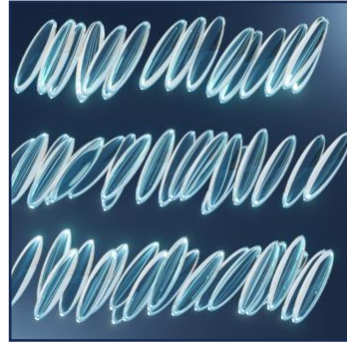
Cell
membrane

Thermotropic rod-like LCs

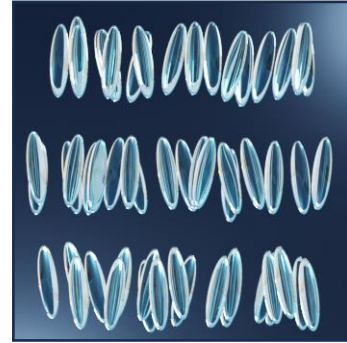
crystal



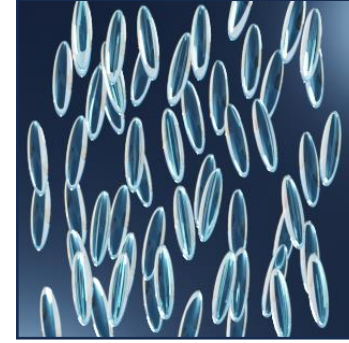
smectic C



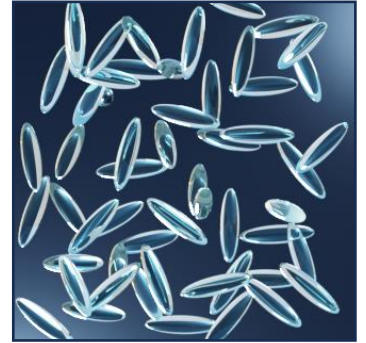
smectic A



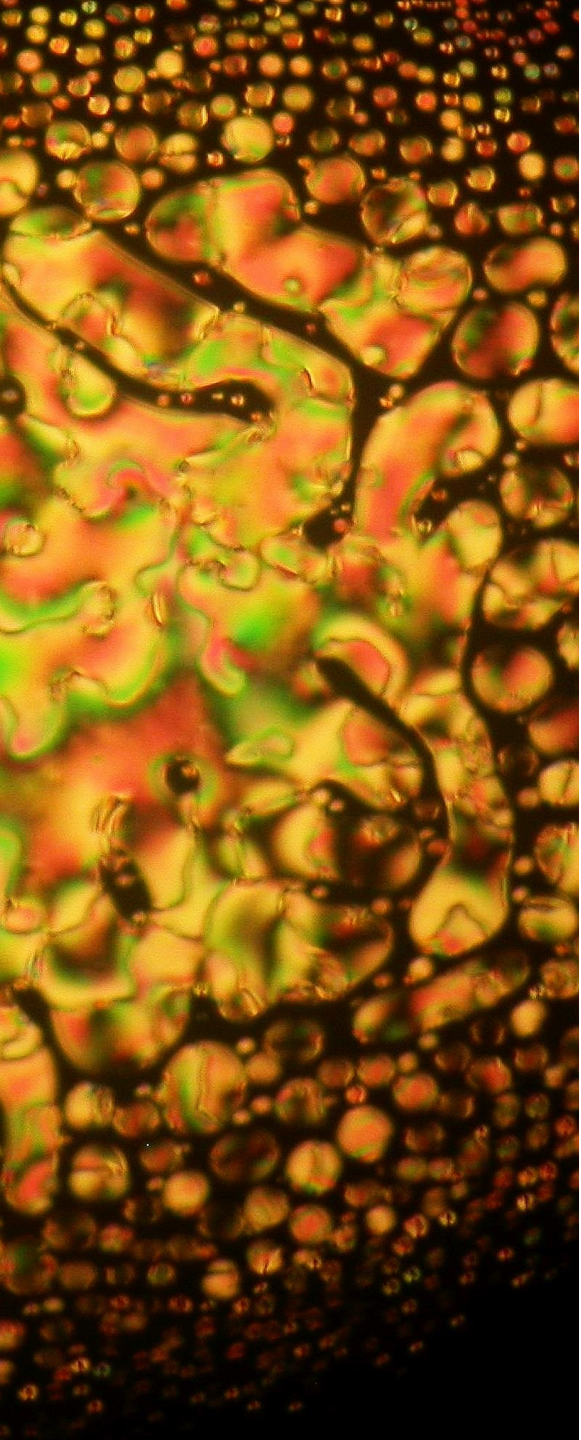
nematic



isotropic
liquid

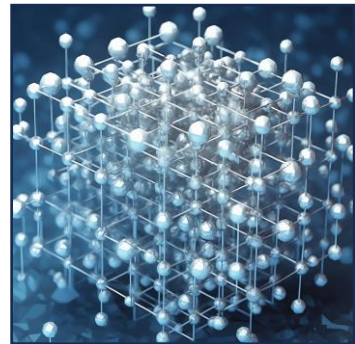


Temperature ↗

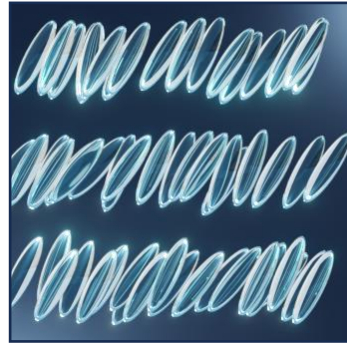


Thermotropic rod-like LCs

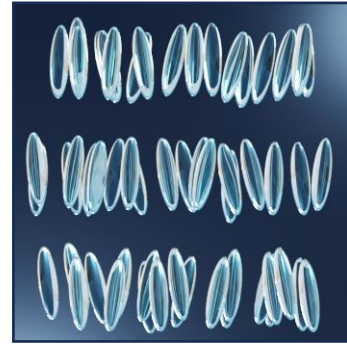
crystal



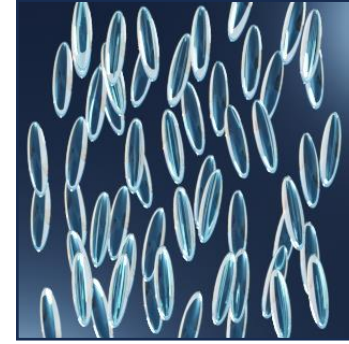
smectic C



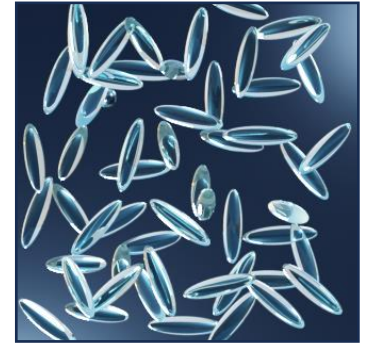
smectic A



nematic



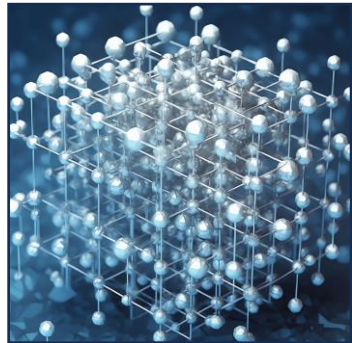
isotropic
liquid



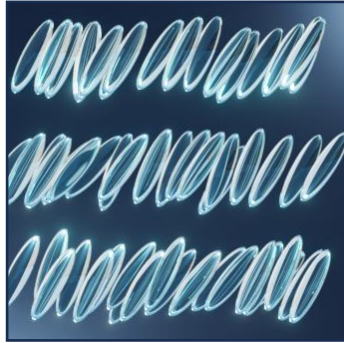
Temperature ↗

Thermotropic rod-like LCs

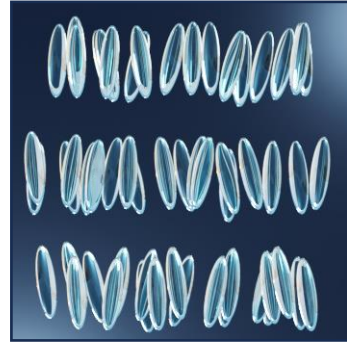
crystal



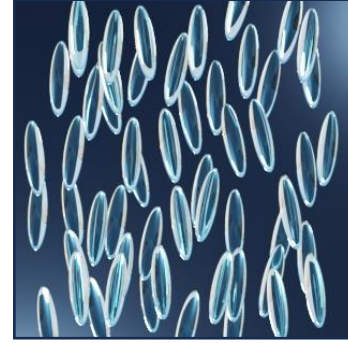
smectic C



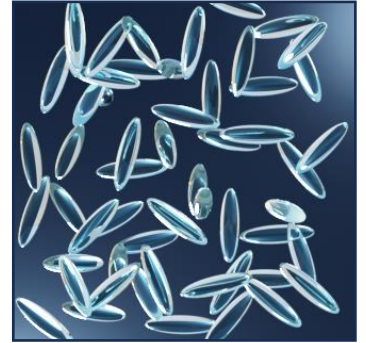
smectic A



nematic



isotropic
liquid



Temperature ↗

Order ↗



Thermotropic rod-like LCs

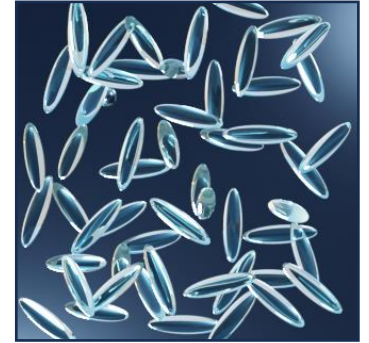
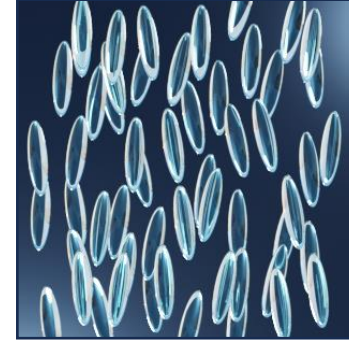
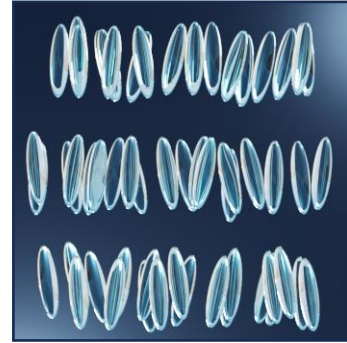
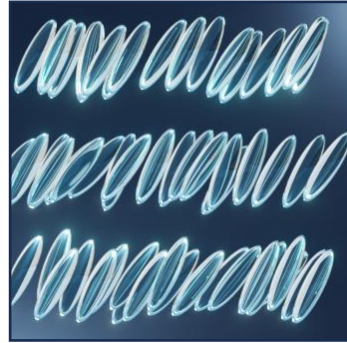
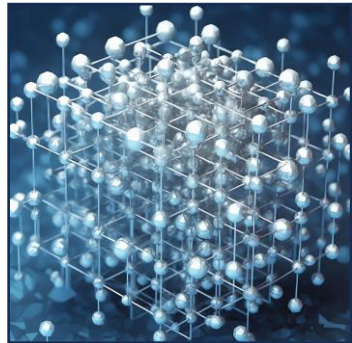
crystal

smectic C

smectic A

nematic

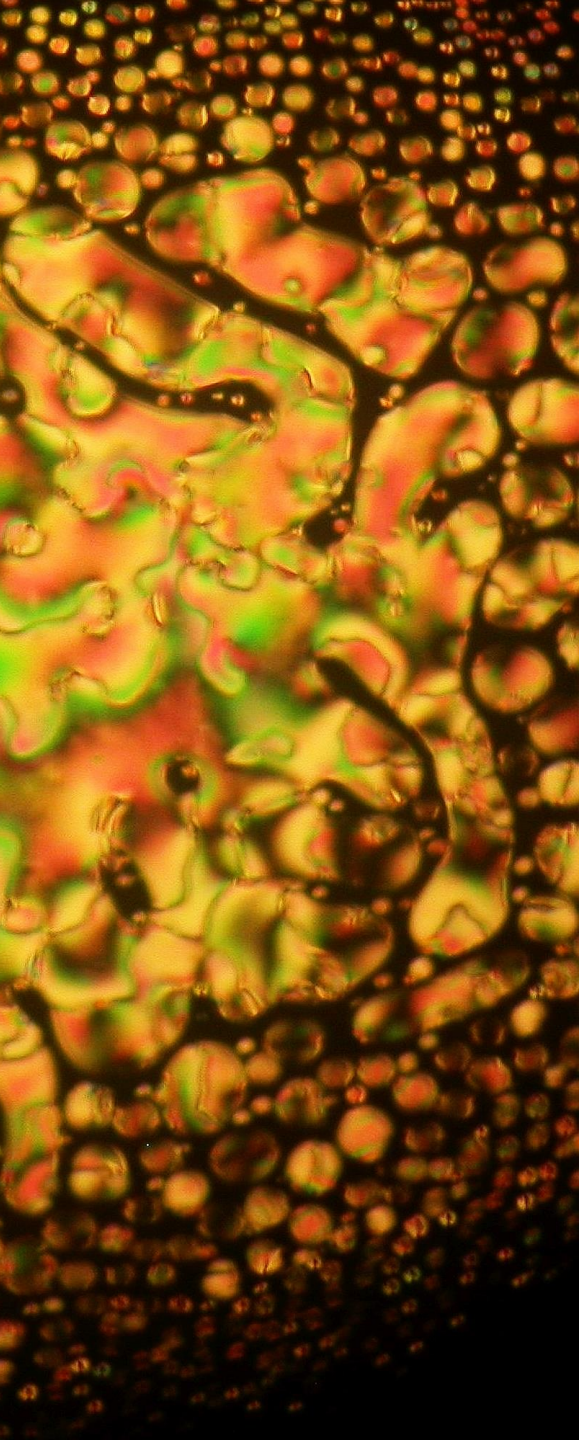
isotropic
liquid



Temperature ↗

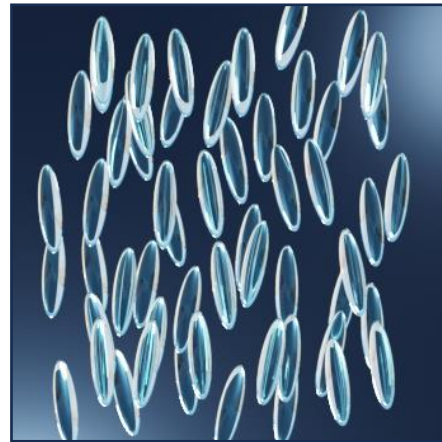
Order ↗



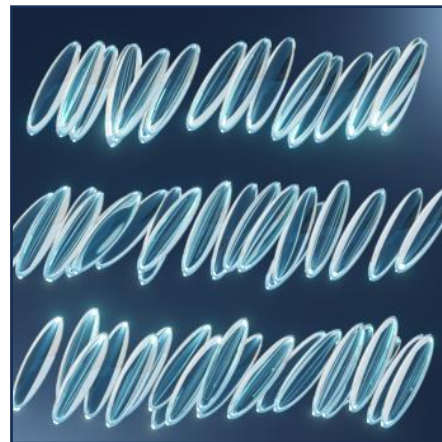


Thermotropic rod-like LCs

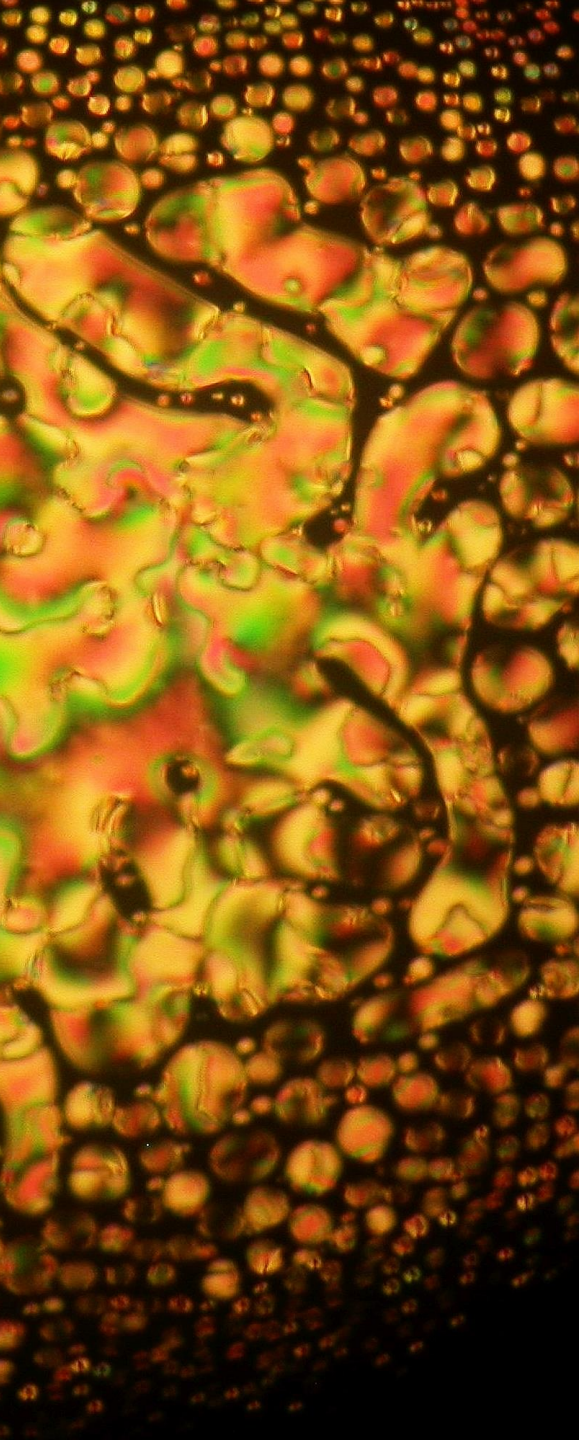
chirality in the system – helical superstructure



nematic

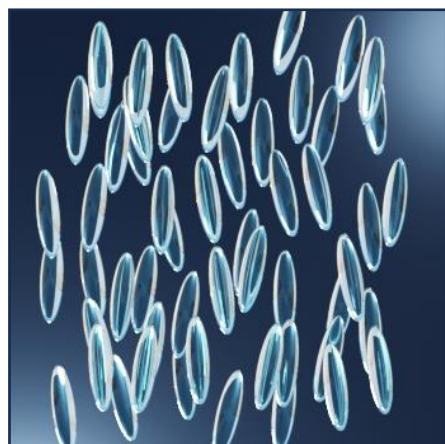


Smectic C



Thermotropic rod-like LCs

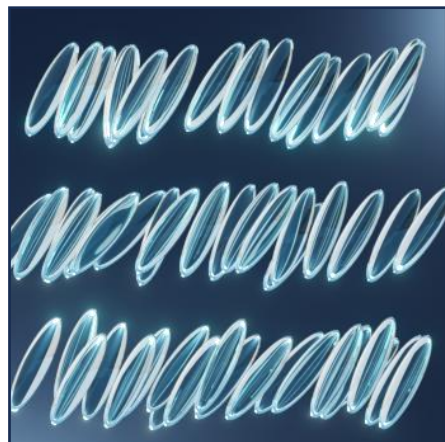
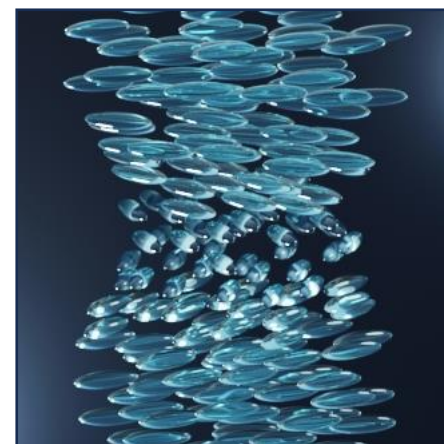
chirality in the system – helical superstructure



nematic



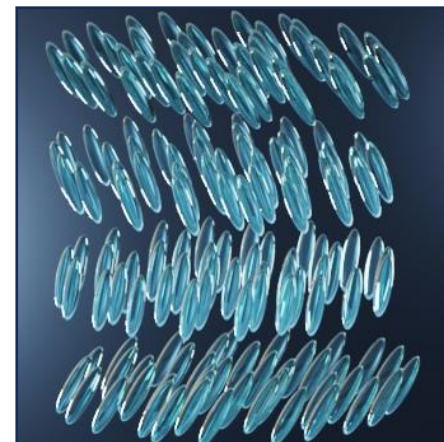
cholesteric

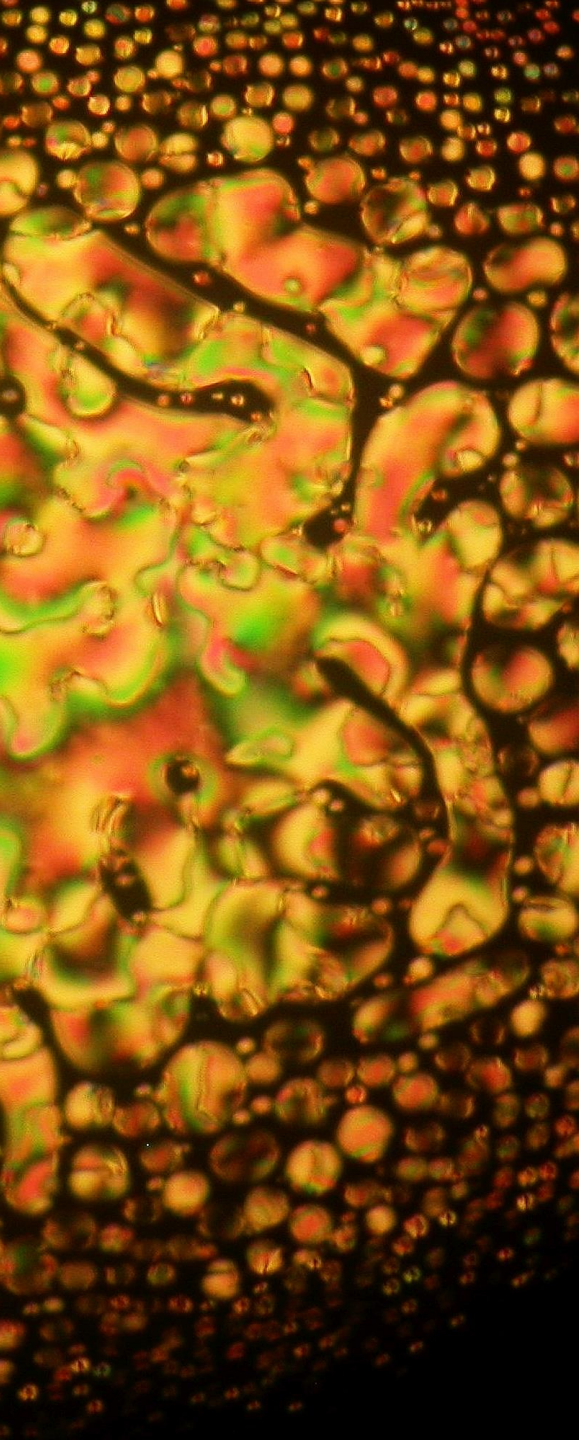


Smectic C



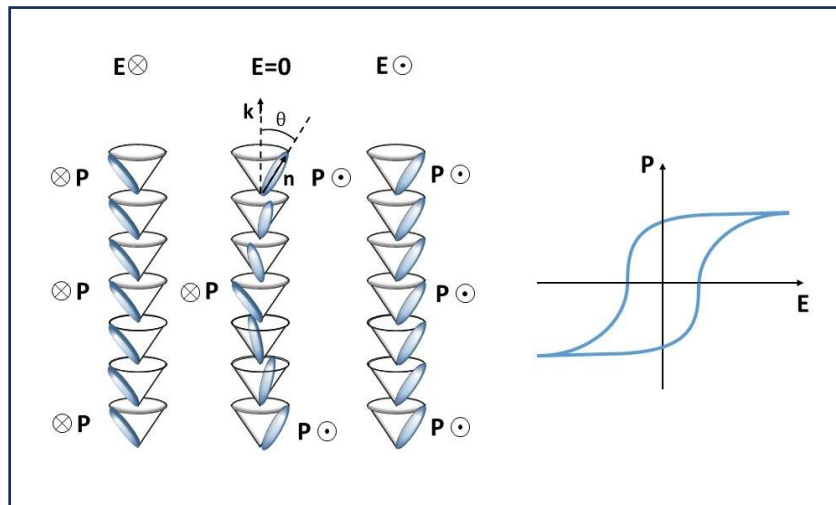
Smectic C*



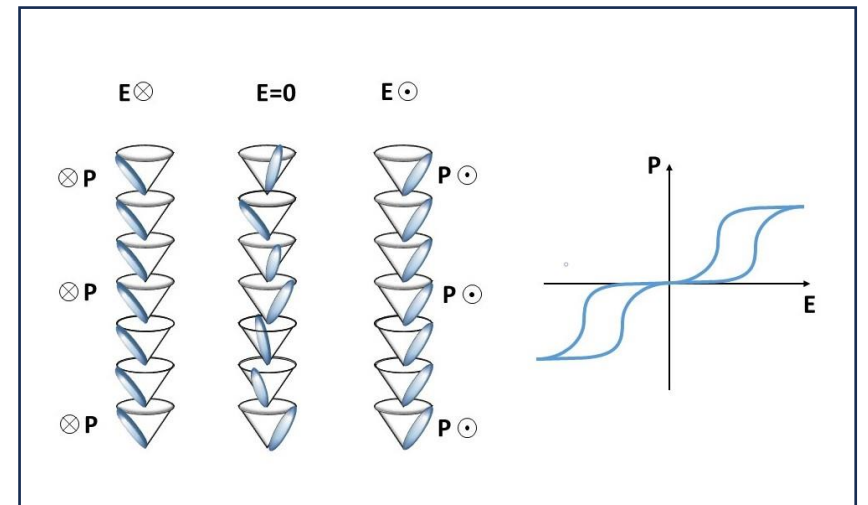


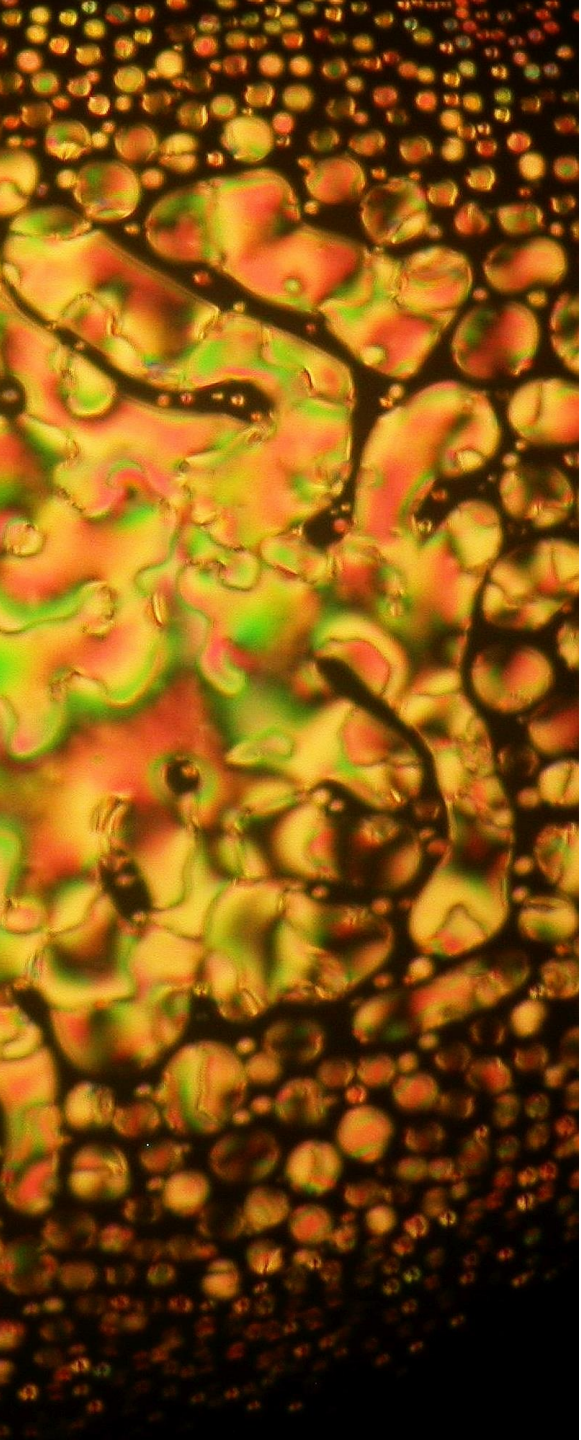
Smectic C*: ferroelectricity and antiferroelectricity

1975 - R.B. Meyer,
ferroelectricity in
SmC* phase

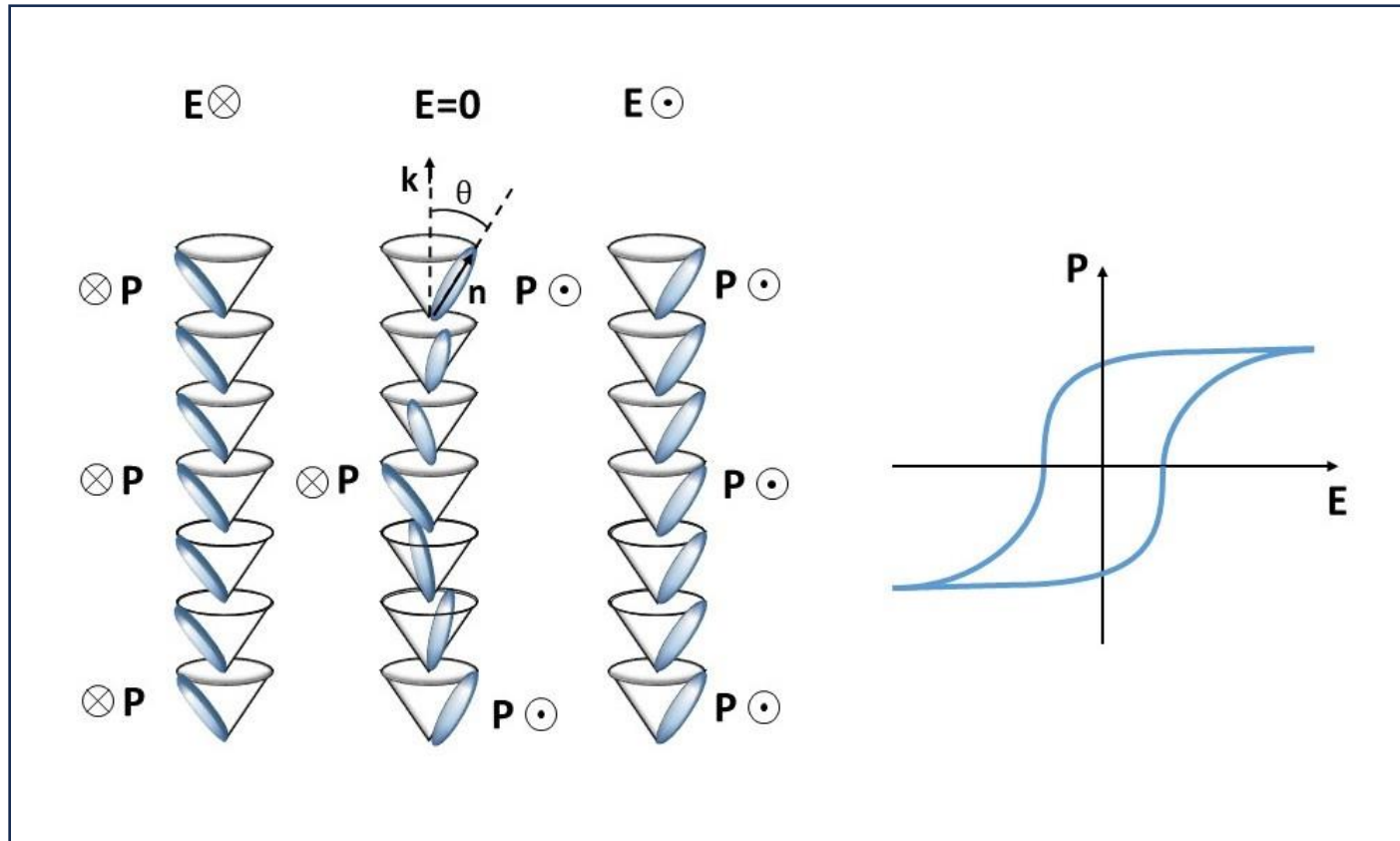


1989 - A.D.L. Chandani
and H. Takezoe,
antiferroelectric SmC_A*

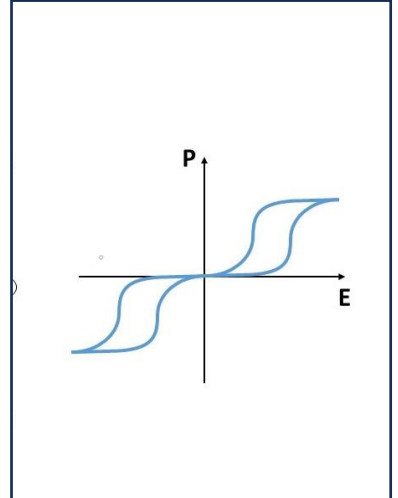
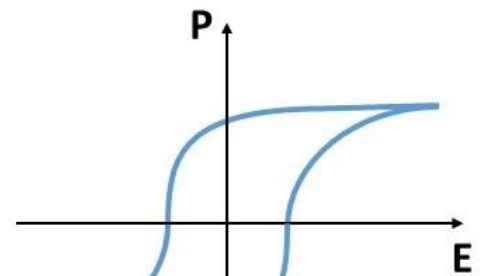


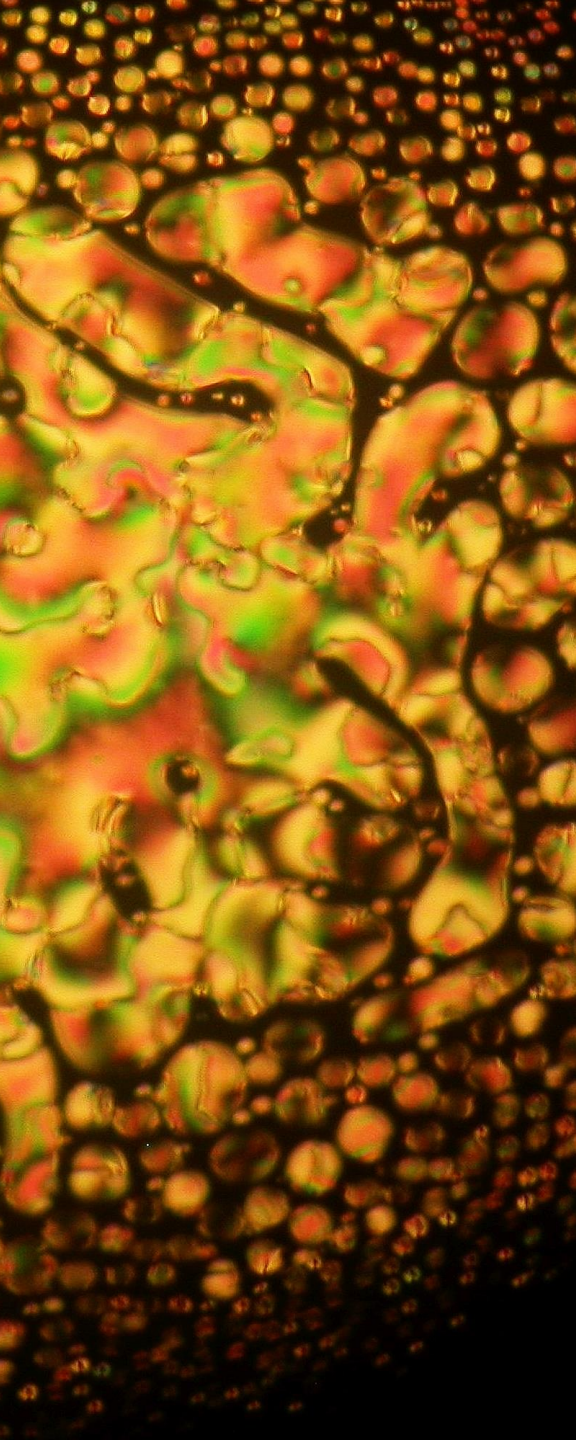


Smectic C*: ferroelectricity and antiferroelectricity



L. Chandani
oe,
tric SmCA*

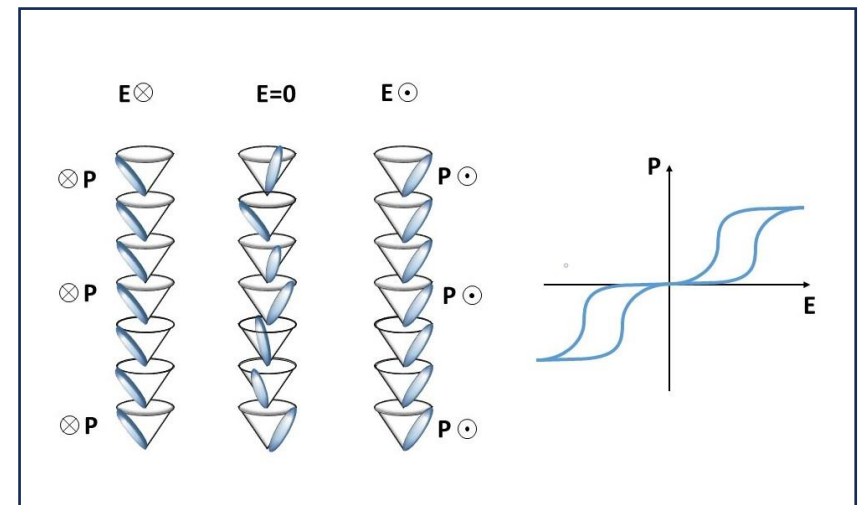
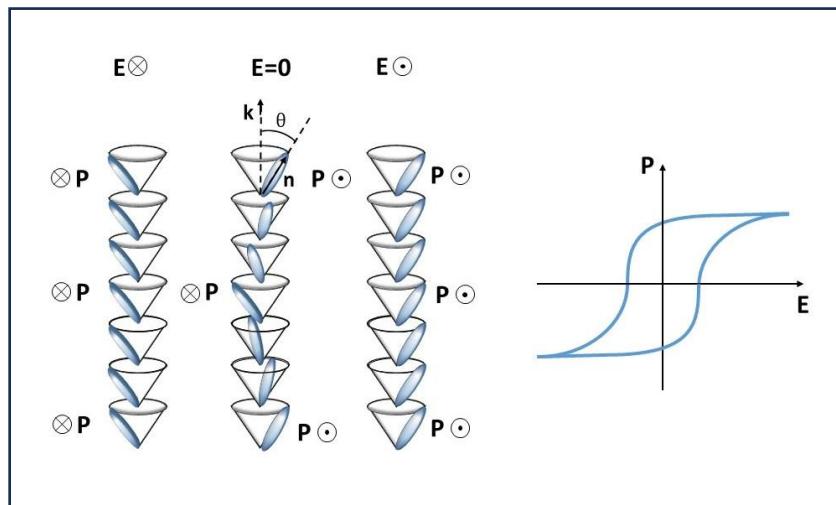


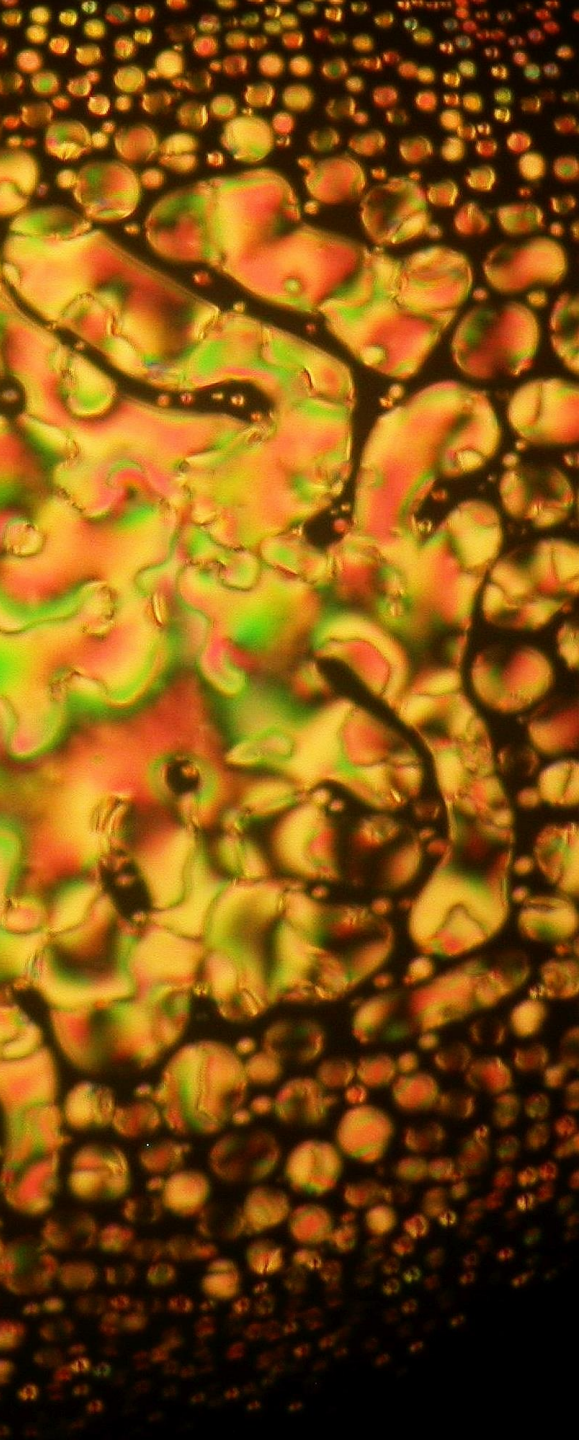


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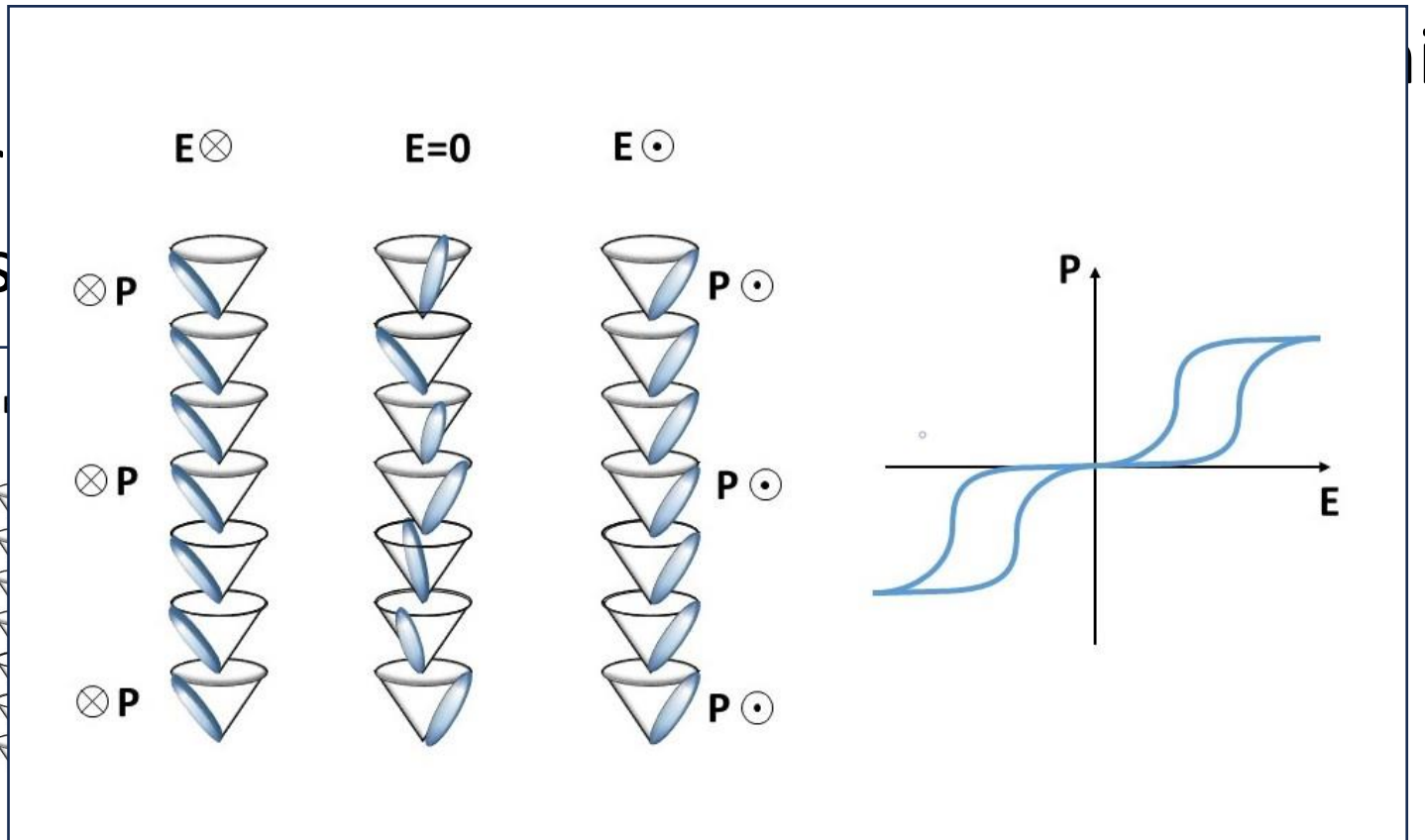
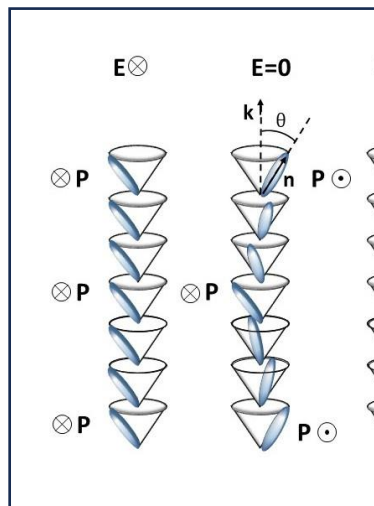
1989 - A.D.L. Chandani
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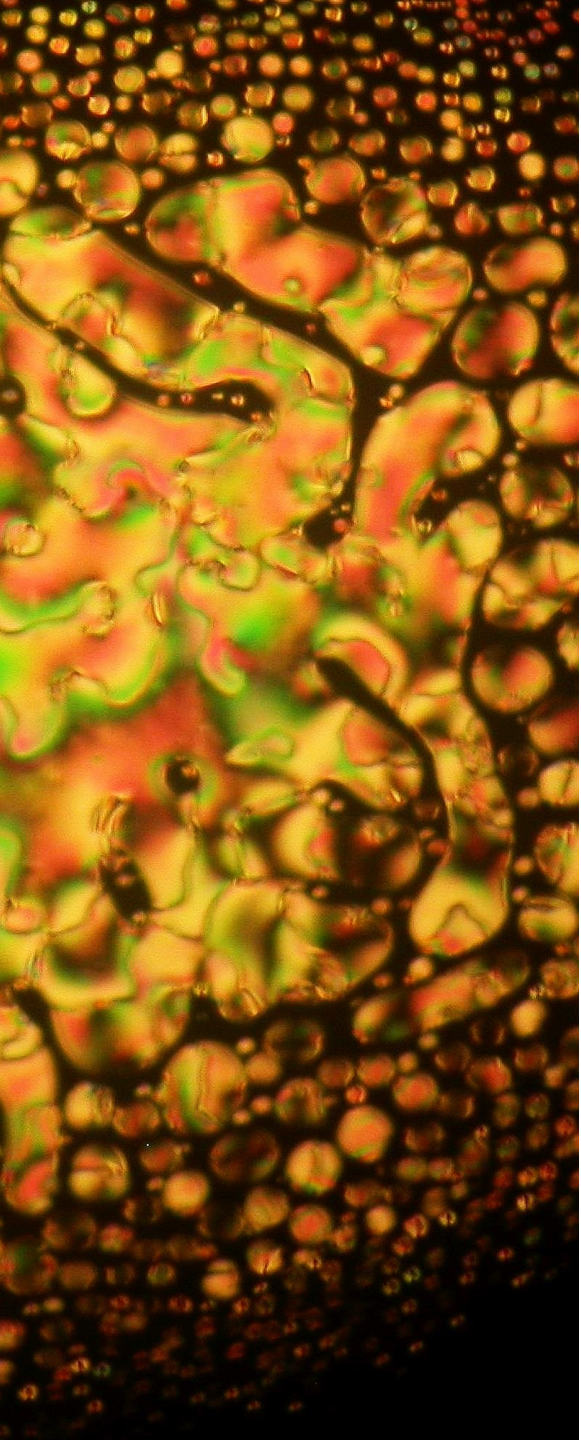




Smectic C*: ferroelectricity and antiferroelectricity

1975 - R. ...
ferroelectr
SmC* phas

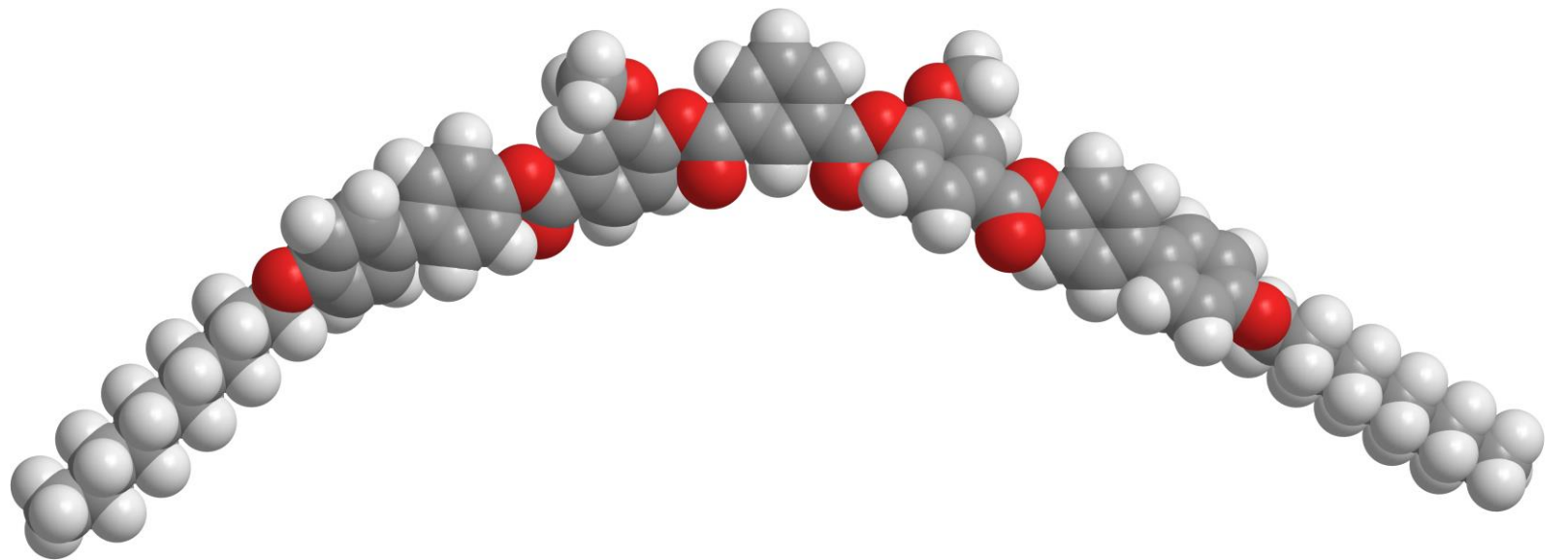




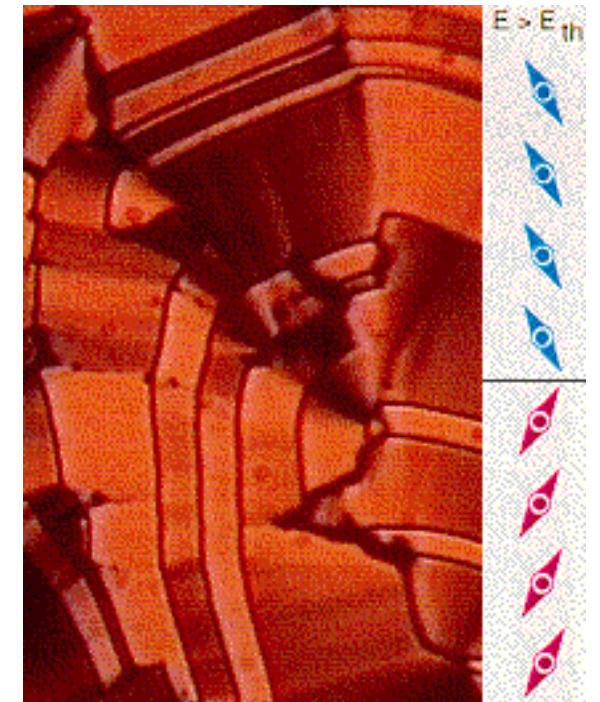
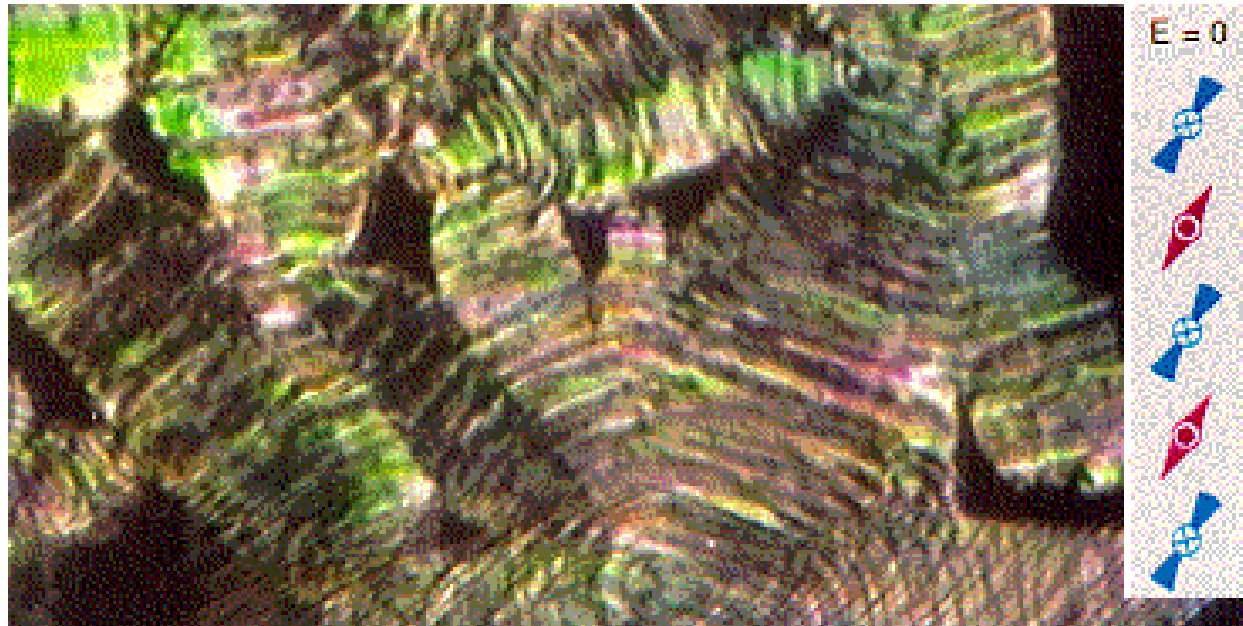
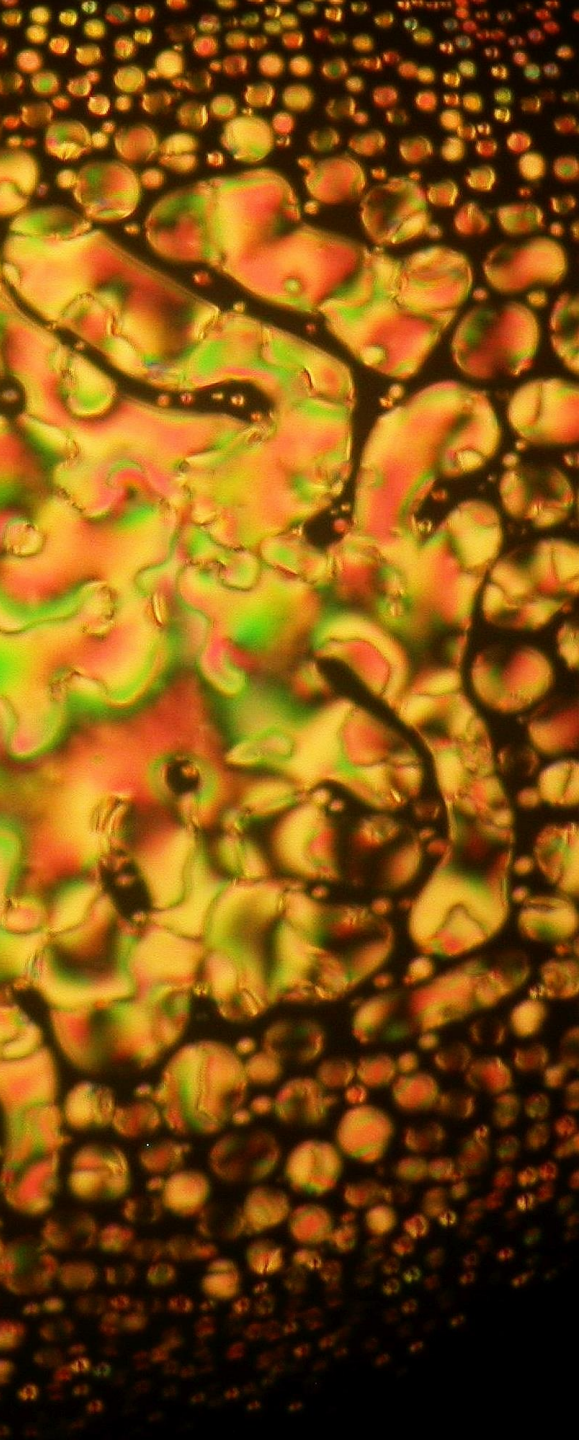
Ferroelectricity without chirality: banana-shaped LCs

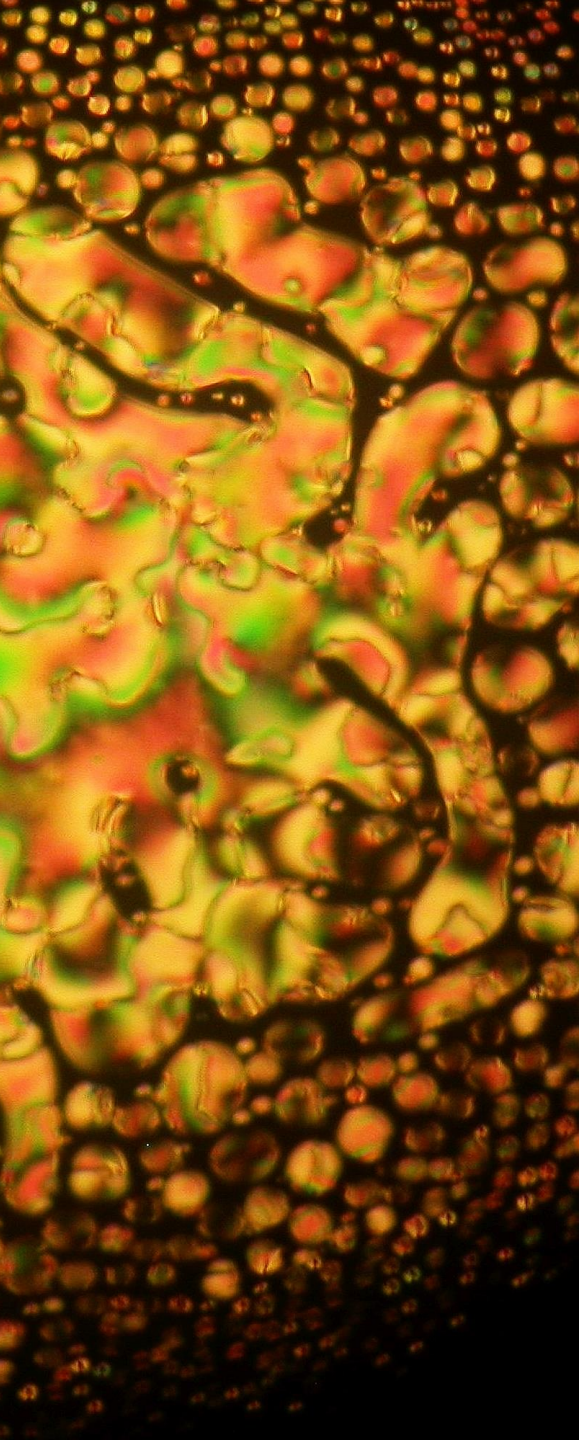
1929 – D. Vorländer, first bent-core LCs

1996 – Niori, Takezoe, switching in bent-core LCs



Electric field switching for the SmCP phase of banana-shaped LCs





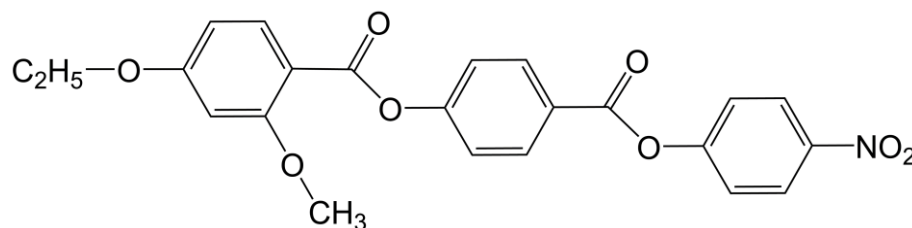
Ferroelectric nematics: new era for applications

1916 – Max Born, theoretical prediction

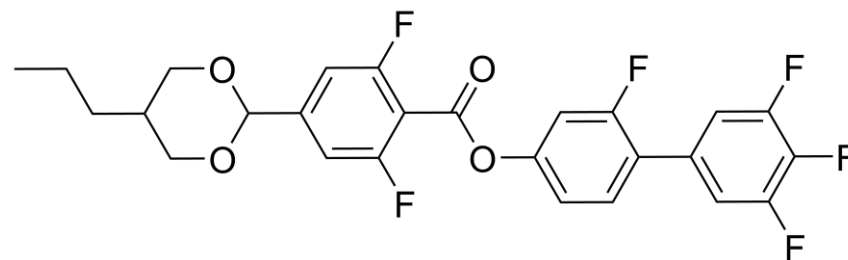
Ferroelectric nematics: new era for applications

1916 – Max Born, theoretical prediction

2017 – R. Mandle et al., Nishikawa et al.
synthesis of the first ferroelectric nematics

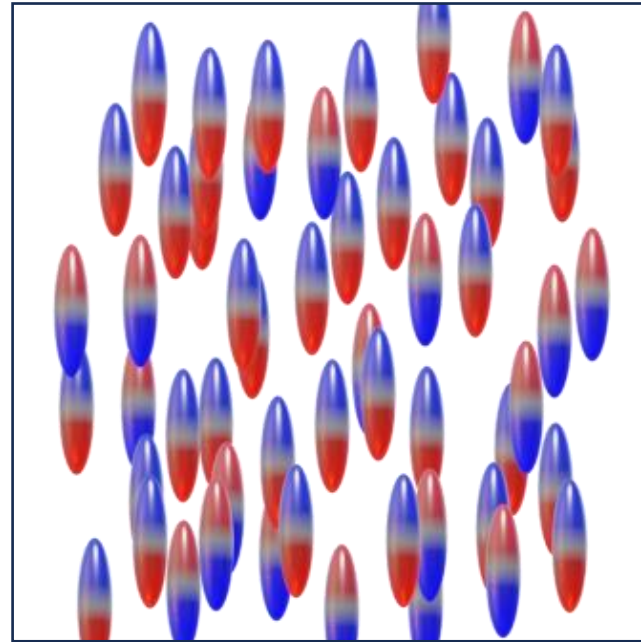


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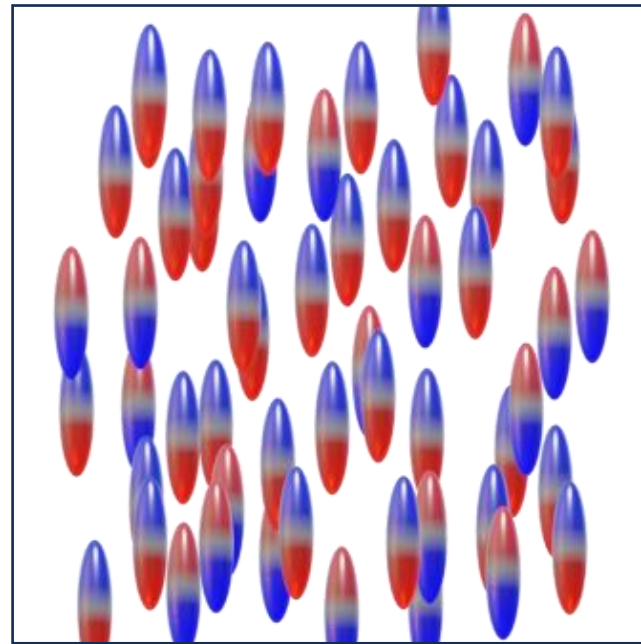
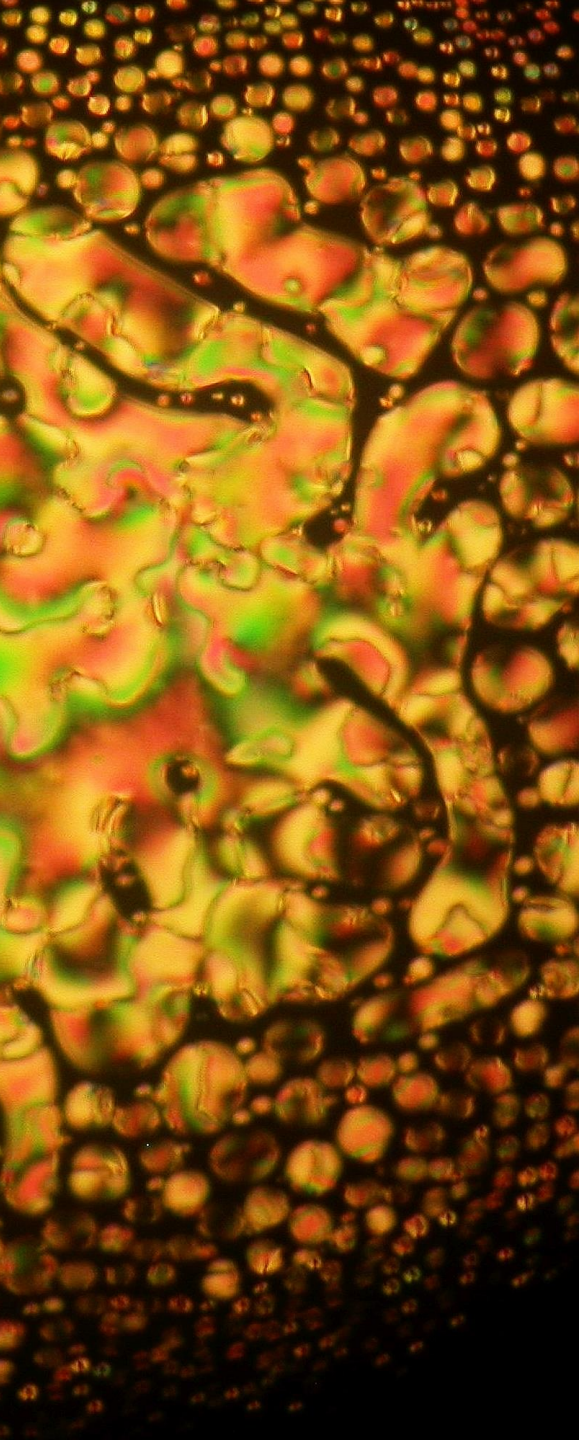
Ferroelectric nematics: new era for applications



ordinary nematic

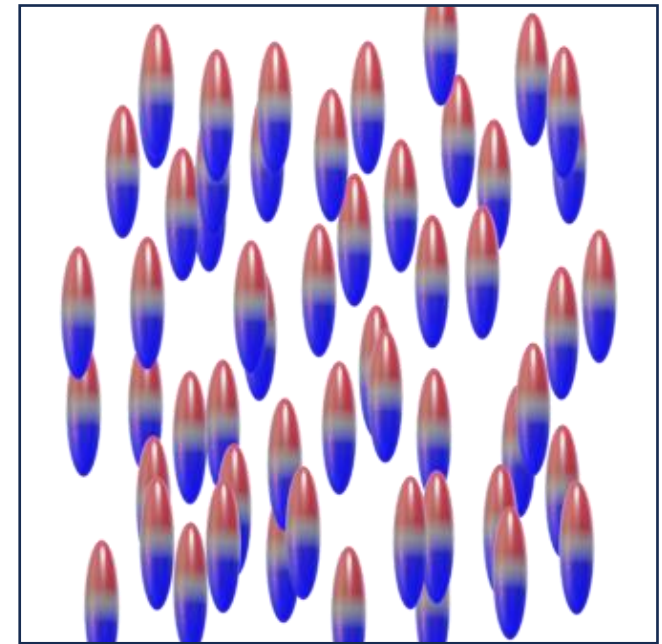
$$n = -n$$

Ferroelectric nematics: new era for applications



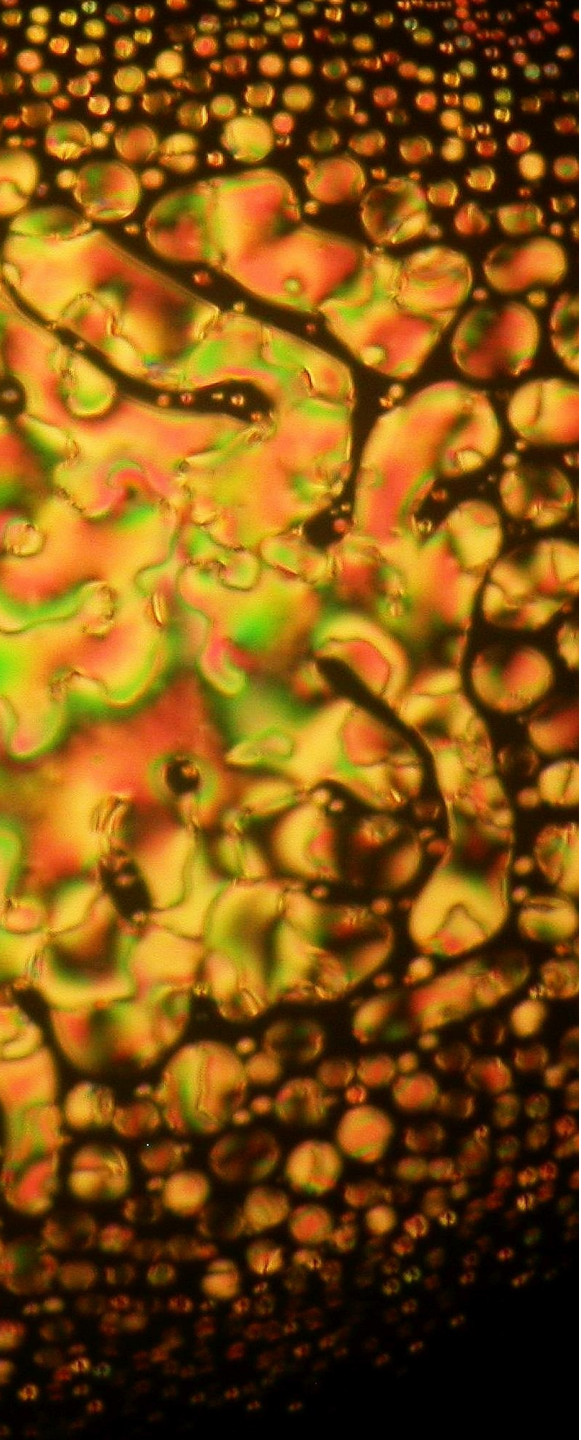
ordinary nematic

$$n = -n$$



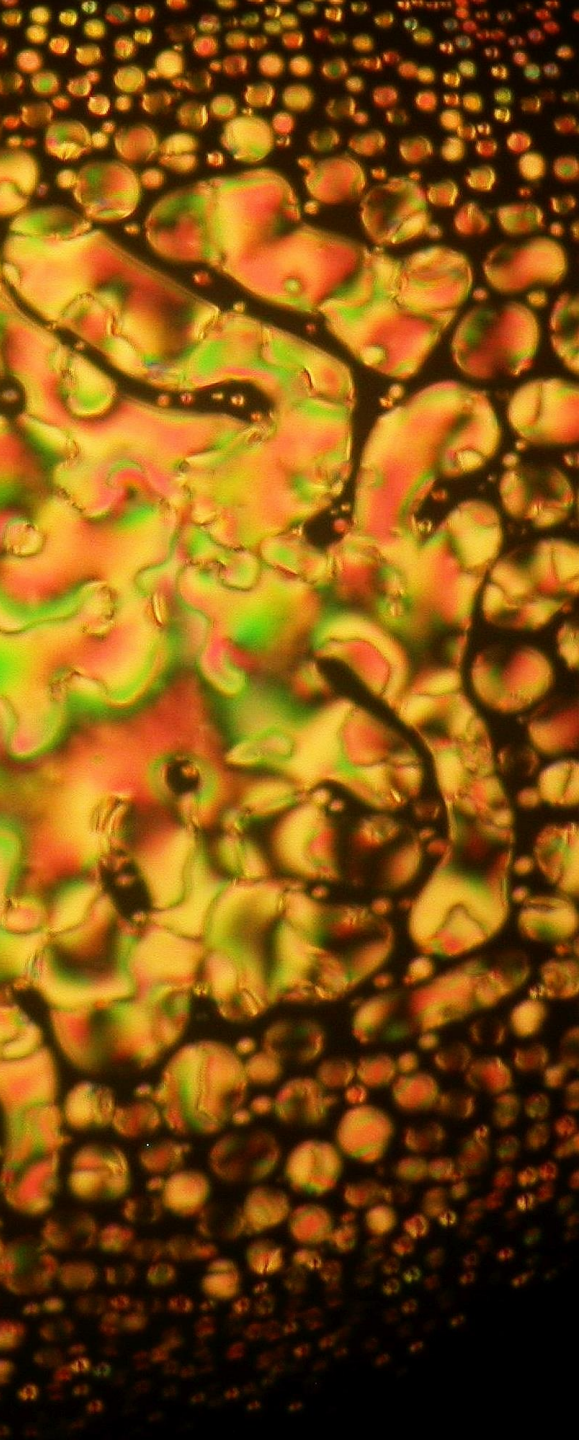
ferroelectric nematic

$$n \neq -n$$



Ferroelectric nematics: new era for applications

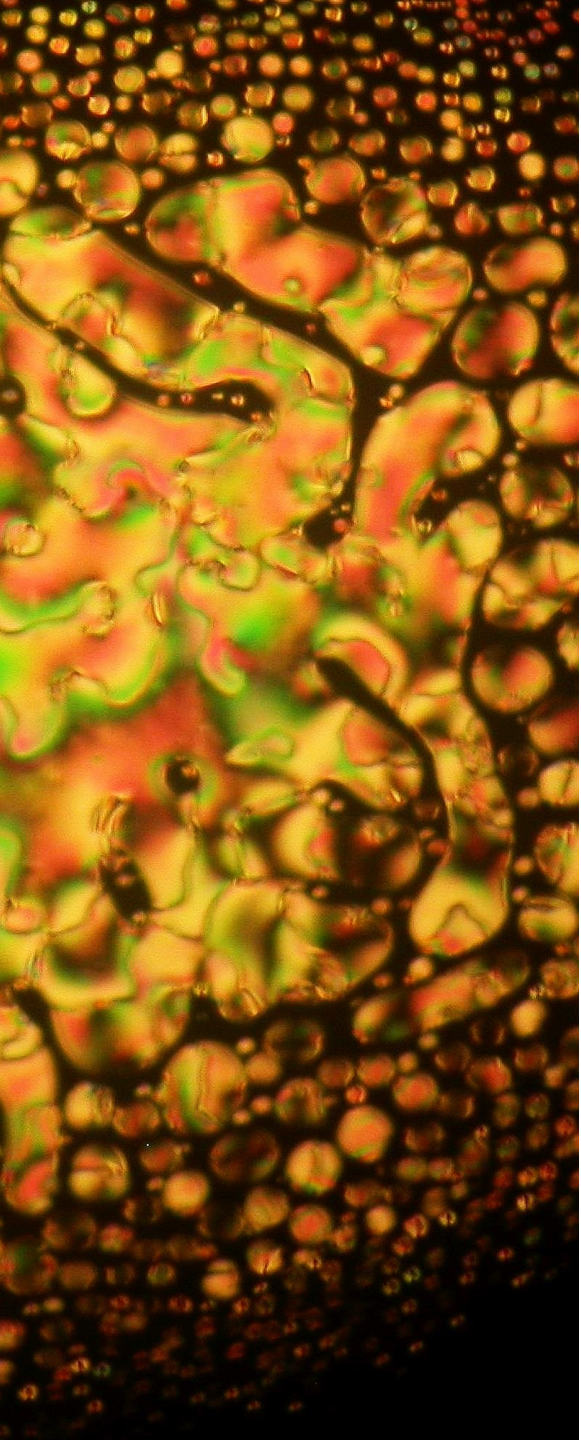
Advantages:



Ferroelectric nematics: new era for applications

Advantages:

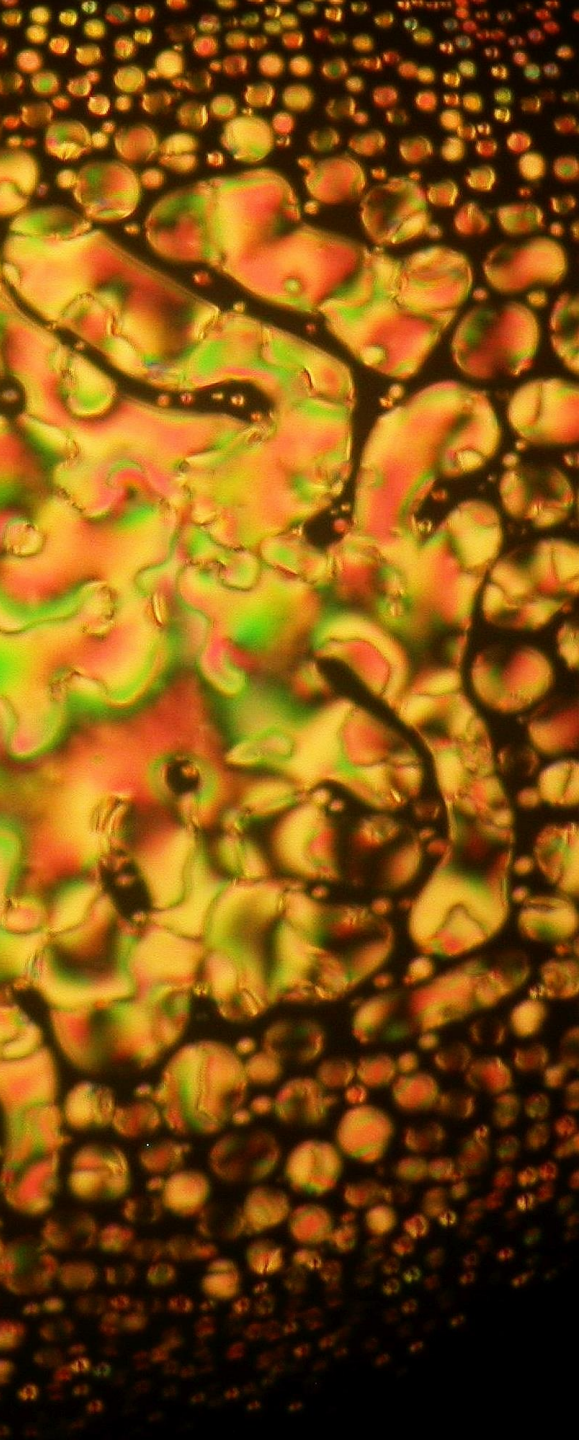
- giant permittivity



Ferroelectric nematics: new era for applications

Advantages:

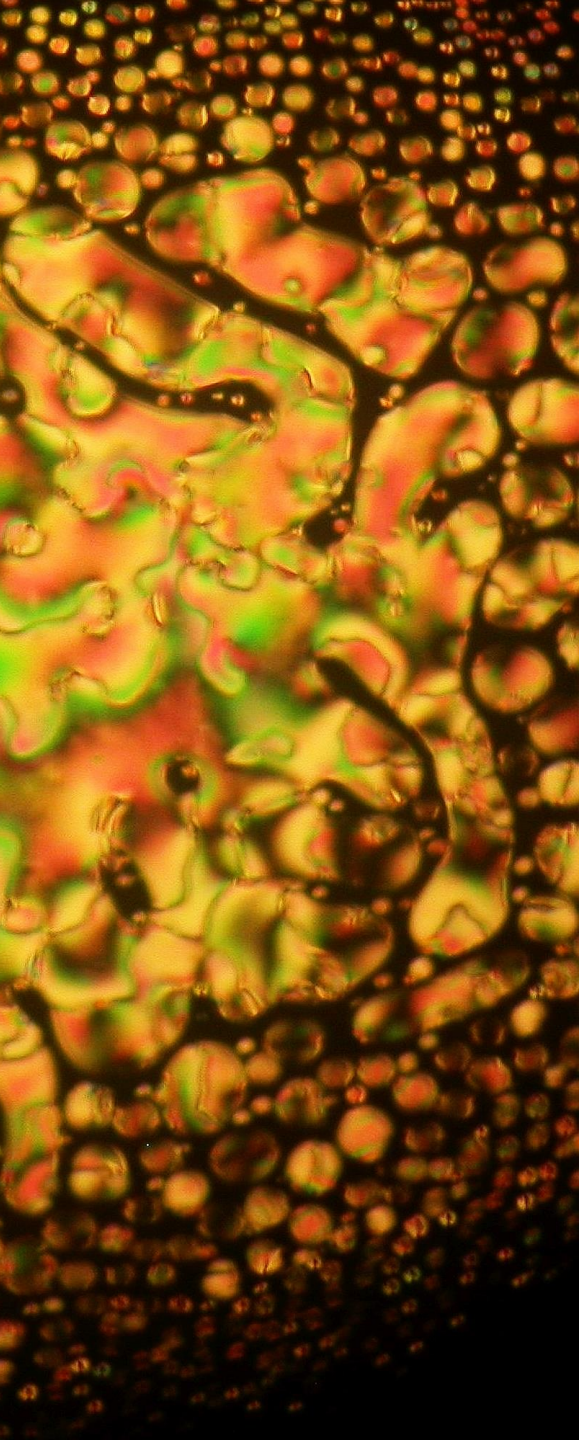
- giant permittivity
- large SHG coefficient



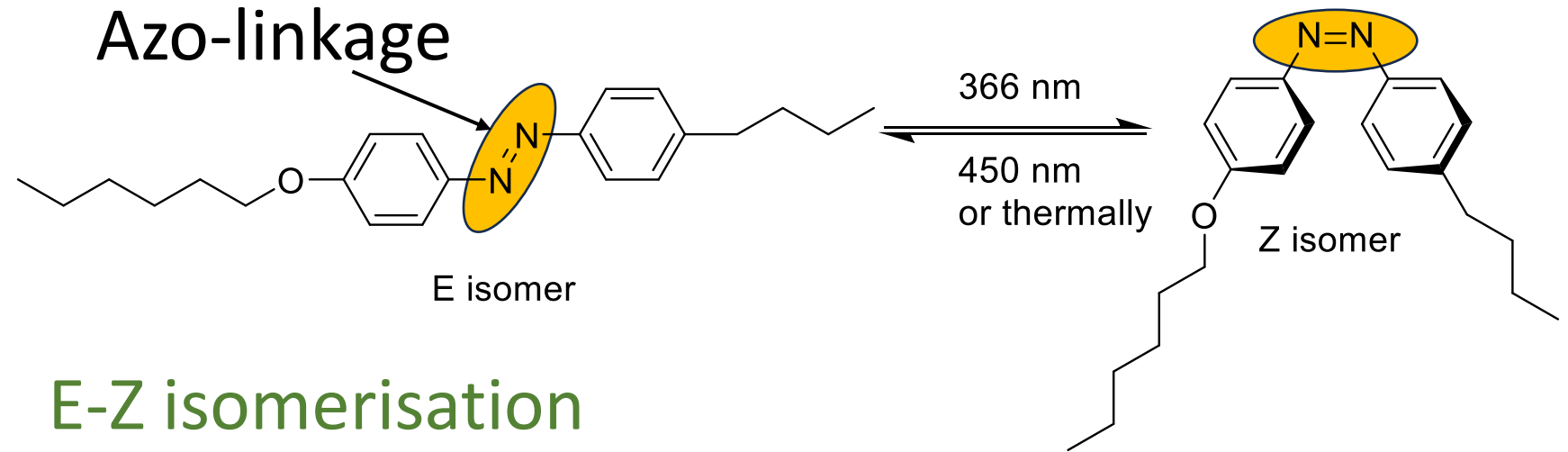
Ferroelectric nematics: new era for applications

Advantages:

- giant permittivity
- large SHG coefficient
- large polarization values comparable to solid ferroelectrics



Photosensitive LCs



E-Z isomerisation



nematic

illumination



liquid

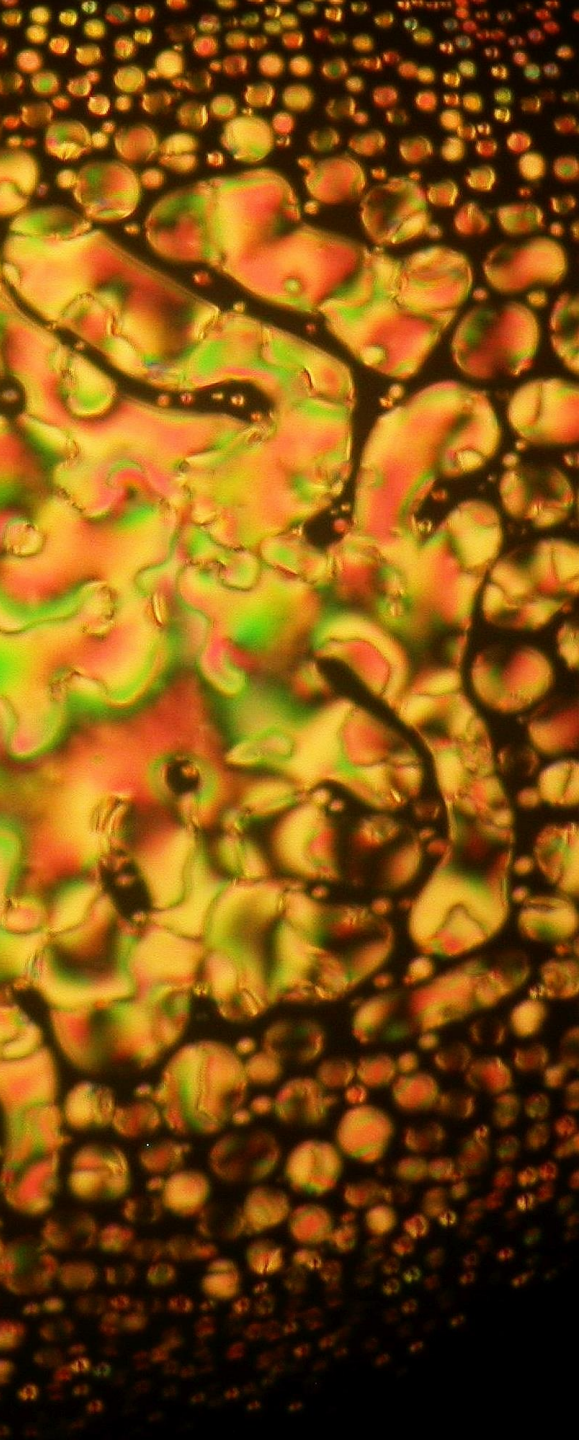
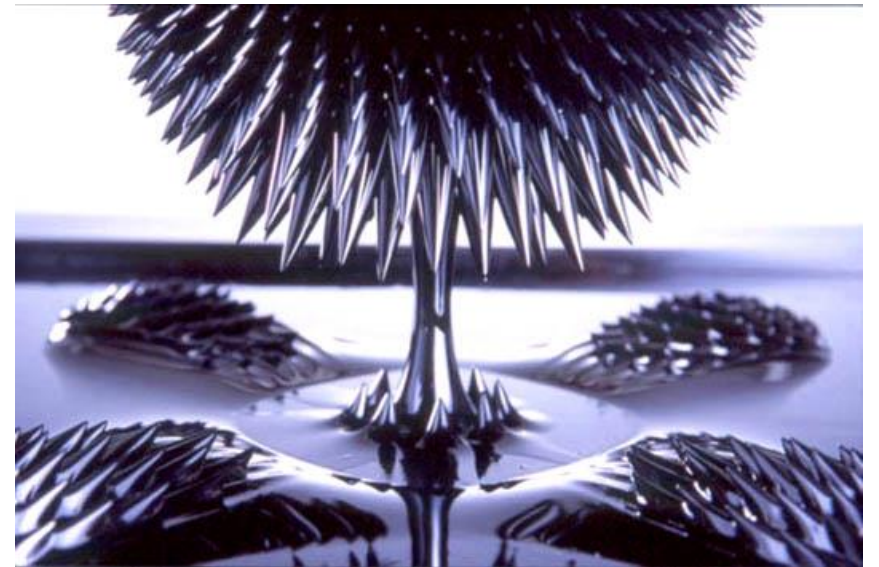
Hybrid systems: nanoparticles in LC host

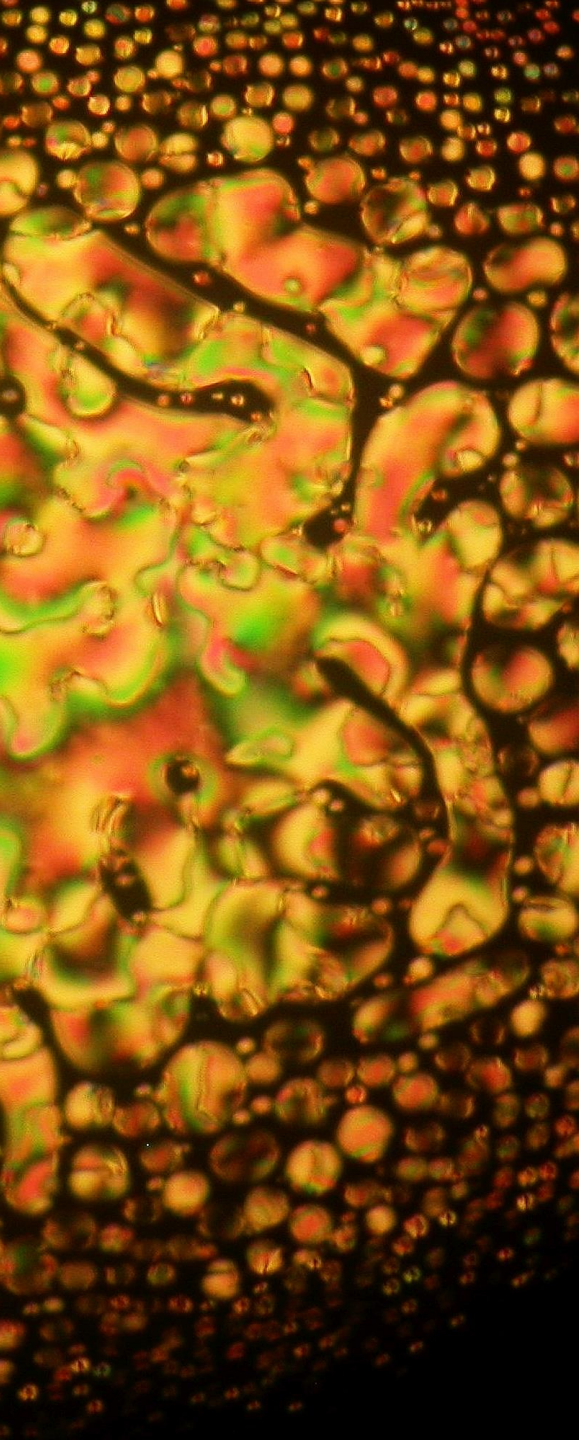
Various **shapes**:

- spherical
- rod-shaped
- platelet

Material:

- magnetic
- metal (golden, silver, etc.)
- ferroelectric (barium titanate, etc.)

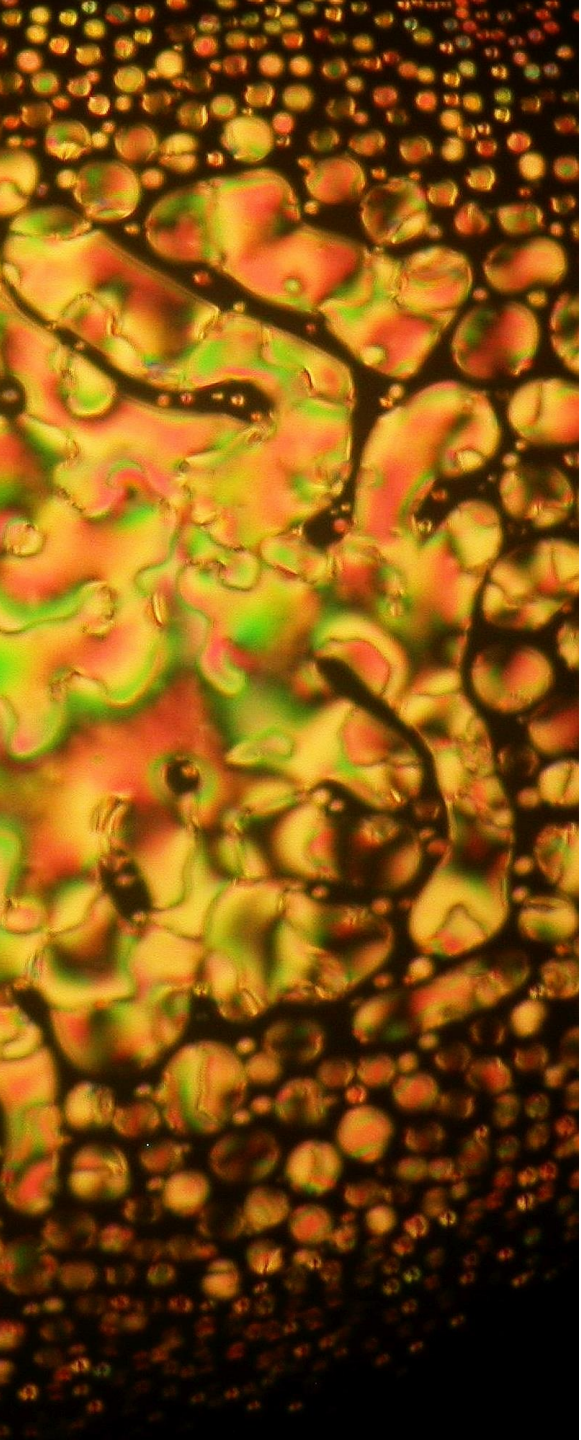




Acknowledgements:



Magneto-electric liquid
Better sensing



Acknowledgements:

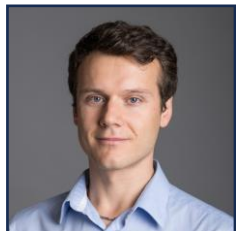
Colleagues:



Vladimíra Novotná



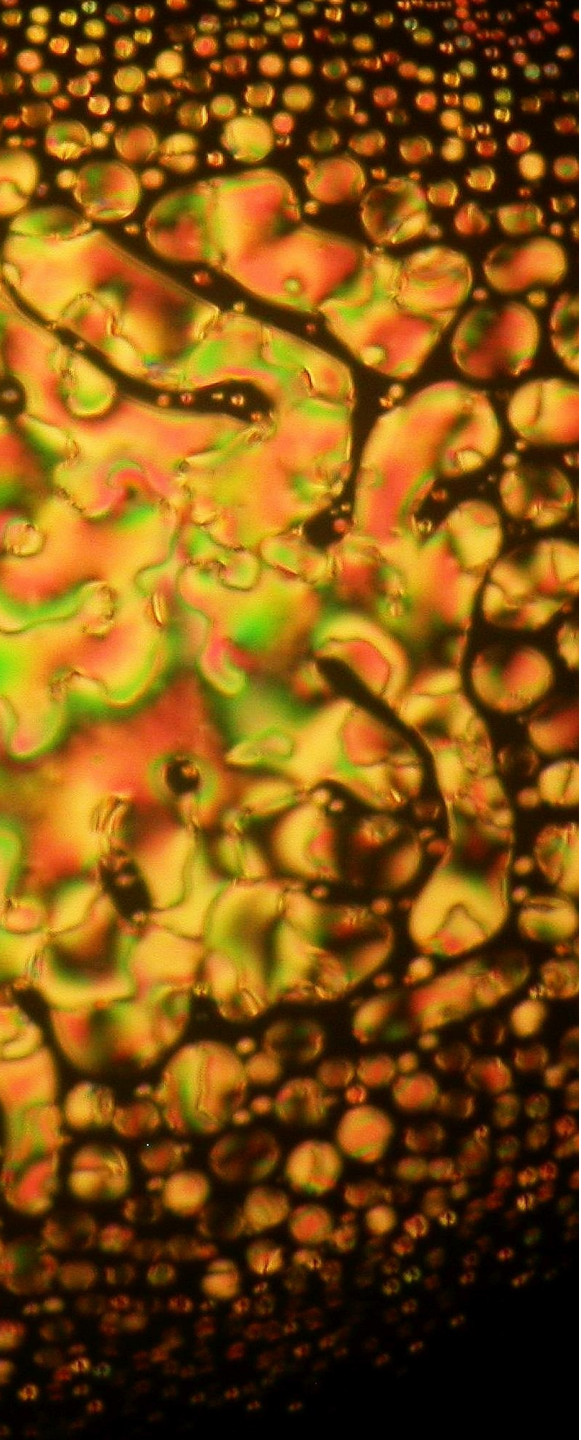
Alexej Bubnov



Matrin Cigl



Magneto-electric liquid
Better sensing



Acknowledgements:

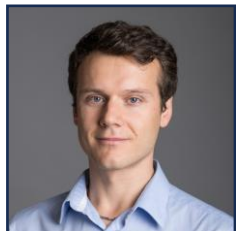
Colleagues:



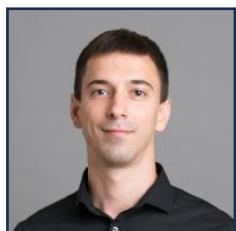
Vladimíra Novotná



Alexej Bubnov



Matrin Cigl

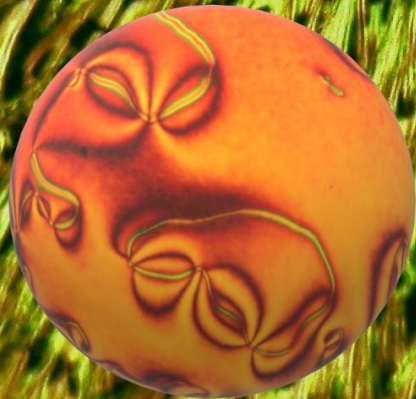


Vladimír Pushkarev



Magneto-electric liquid
Better sensing

Thank you



for your attention!