

Experimental assessment of interactions between liquid crystal 4-cyano-4'-hexylbiphenyl and magnetoferritin

Lucia Balejíková, Veronika Lacková, Natália Tomašovičová, Jozef Kováč and Peter Kopčanský

Description of used experimental methods

Chemicals

4-n-Hexyl-4'-cyanobiphenyl (6CB), ammonium ferrous sulphate hexahydrate ((NH₄)₂Fe(SO₄)₂·6H₂O), equine spleen apoferritin in 0.15 M NaCl, ethanol (C₂H₆O), hydrogen peroxide (H₂O₂), N-(1,1-Dimethyl-2-hydroxyethyl)-3-amino-2-hydroxypropanesulfonic acid (AMPSO), sodium hydroxide (NaOH), and trimethylamine N-oxide (Me₃NO) were obtained from SIGMA-Aldrich, Coomassie brilliant blue from Fluka, hydrochloric acid (HCl) from ITES, potassium thiocyanate (KSCN) from Slavus and phosphoric acid (H₃PO₄) from Centralchem, demineralised (deionized) water was used throughout the experiment for preparation of chemical aqueous solutions.

Magnetoferritin preparation

MFe with different iron loadings was synthesized by controlled additions of ferrous ions (0.1 M solution of ((NH₄)₂Fe(SO₄)₂·6H₂O) into the empty protein shell of native apoferritin, dispersed in 0.05 AMPSO buffer adjusted by 2 M NaOH solution to final pH value 8.6. Precise synthesis technology is described elsewhere [1].

Quantitative determination of loading factor

Quantitative determination of loading factor (LF) was performed UV-VIS spectrophotometrically using SPECORD 40 device (Analytik Jena) by method described in our previous works [1]. Final LF was calculated according to the equation:

$$LF = \frac{c_m^{Fe} \cdot M_{NA}}{c_m^{NA} \cdot M_{Fe}} \quad (1)$$

In Eq.1 c_m^{Fe} a c_m^{NA} are mass concentrations of iron atoms and apoferritin biomacromolecules, M_{NA} means molecular weight of native apoferritin (i.e. ~ 481200 Da, value obtained from SIGMA-Aldrich) and M_{Fe} represents standard atomic weight of iron atom (i.e. ~ 55.845 Da).

Measurement of hydrodynamic size

The average hydrodynamic diameter $\langle D_{HYDR} \rangle$ of MFer particles in aqueous colloidal solution was measured by Zetasizer NanoZS (Malvern Instruments, UK), using dynamic light scattering (DLS) also known as photon correlation spectroscopy or quasi-elastic light scattering. Detailed description of method principle and measurements can be found in the latest work [1].

Zeta potential measurements

Zeta potential, ζ , parameter of the colloidal stability, was obtained using Laser Doppler velocimetry combined with electrophoresis on ZS 3600 (Malvern Instruments) at 25°C by commonly used procedure [1].

Freeze drying

The liquid MFer samples with three different LFs were weighed, placed in a freezer at -20°C and after 8 hours attached to the lyophilizer (IlshinEurope TFD5503). Lyophilization run for 24 hours to obtain powders which were subsequently weighed and used for further experiments.

SQUID magnetometry

Magnetic properties of powder MFer samples with tree different LFs were investigated using Superconducting Quantum Interference Device (SQUID) magnetometer (Quantum Design MPMS 5XL). The hysteresis loops on the prepared samples were measured by the help of this equipment at the temperature 290 K in the range of the induction of the magnetic field up to 2 T.

Capacitance measurements

The structural transitions of prepared hybrid systems have been monitored by capacitance measurements in a capacitor made of indium-tin-oxide (ITO) coated glass electrode. A rubbed polyimide coating on the electrodes ensured planar orientation, i.e. the averaged orientation of LC molecules was parallel to the capacitor electrodes. The capacitor with the electrode area of

approximately $0.5 \text{ cm} \times 0.5 \text{ cm}$ has been placed into a thermostat system, regulated with a temperature stability of $0.05 \text{ }^\circ\text{C}$ and the measurements have been done at the temperature of 20°C . The distance between the electrodes (the sample thickness) was $D = 50 \text{ }\mu\text{m}$. The capacitance C was measured at the frequency of 1 kHz by a TiePie Handyscope HS5 instrument, using sinusoidal voltage signal with the amplitude of 0.1 V that was switched to the cell. The Fréedericksz transitions have been provoked either by electric (generated by U) or magnetic field \mathbf{H} (i.e. the magnetic induction $\mathbf{B} = \mu_0\mathbf{H}$; μ_0 is the permeability of vacuum) applied perpendicular to initial orientation of LC molecules. Figure 3 and 4 show the variation of the reduced capacitance $(C-C_0)/(C_{\text{max}}-C_0)$, where C_0 and C_{max} are the capacitance values measured at $\mathbf{H}=0$ and $\mathbf{H} = \mathbf{H}_{\text{max}}$, respectively.

References

- 1 L. Balejčikova, M. Molčan, J. Kováč, M. Kubovčíková, K. Saksler, Z. Mitrova, M. Timko and P. Kopcansky, *J. Mol. Liq.*, 2019, **283**, 39.