



Higher-order molecular control of self-assembling donor-acceptor columnar liquid crystals (DACLCS)

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Optical Properties of DACLCs

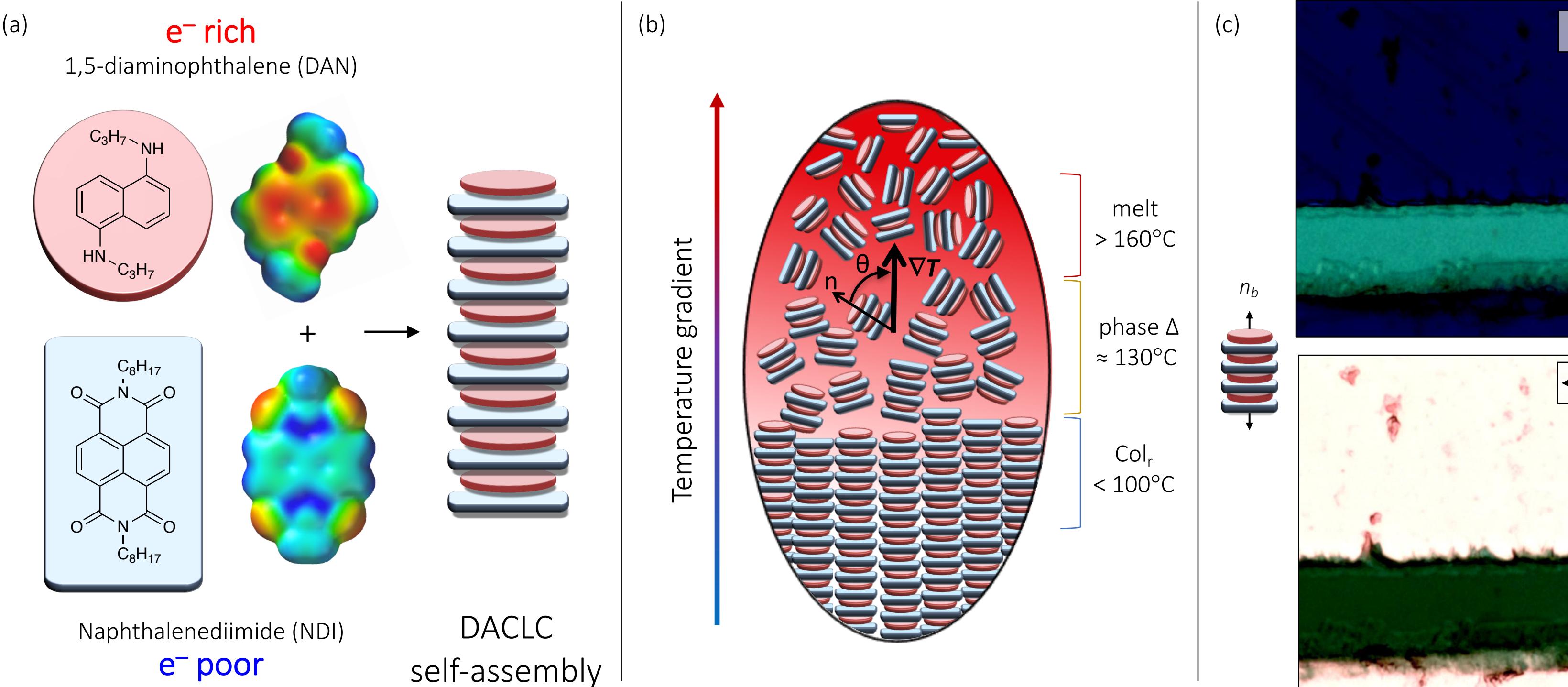


Figure 1. (a) Columnar self-assembly principle; (b) precise control of columnar alignment and re-alignment via induced thermal gradient; (c) dichroic LPL (indicated by arrows) response of aligned regions, with background alignment along n_b and an isotropic (un-aligned) region through the middle.

Core Substituted NDIs

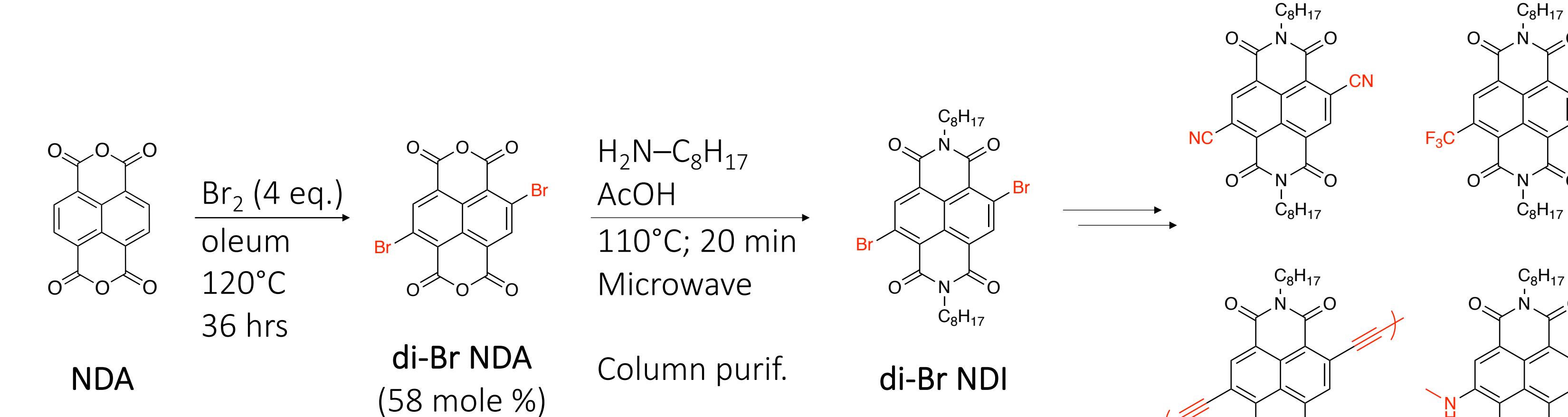


Figure 5. General reaction scheme for synthesis of core di-substituted NDIs.

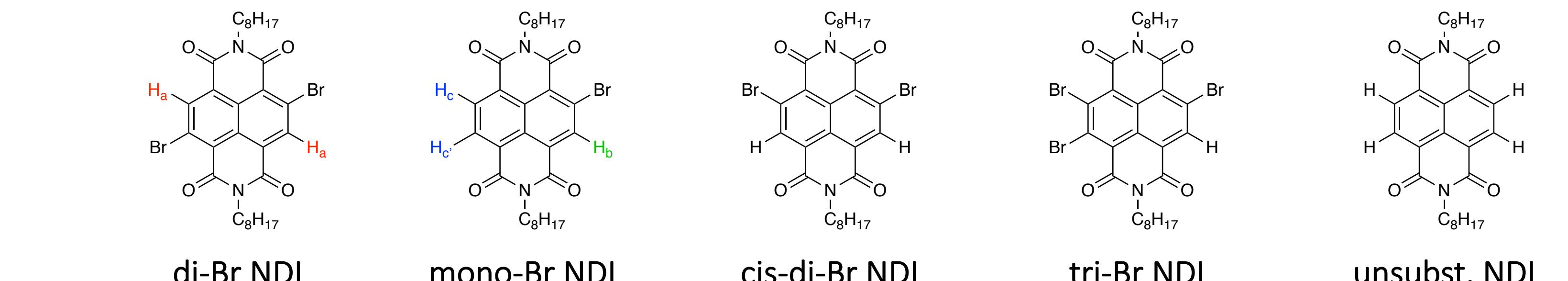


Figure 6. ^1H NMR spectra of (a) predominantly (> 90%) di-brominated and (b) predominantly mono-brominated (cf. Figure 9) NDI. By entertaining reaction schemes that achieve particular bromine substitutions of NDI, we are able to access other species of core-functionalized NDIs with corresponding substitutions.

Core Di-Substituted NDIs

Core di-substitution reaction schemes were used. Successful core di-functionalization is demonstrated by substitution with cyano and fluoro functional groups (Figure 7–8). Core mono-substitution with a cyano functional group was entertained using a modified scheme for di-cyano substitution (Figures 9–10).

Encryption Applications

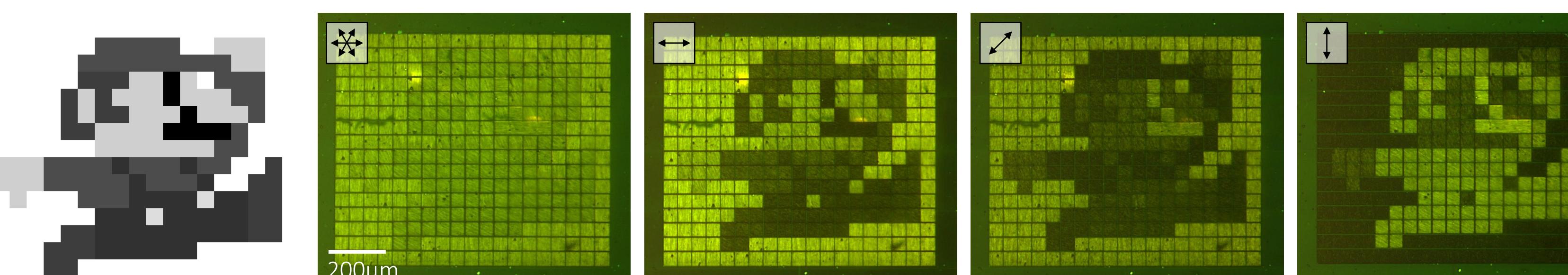


Figure 3. Information in the form of an image can be encoded, stored, and reliably read-out using a DACLC medium. Importantly, correct data readout is dependent on applying the correct angle of LPL.

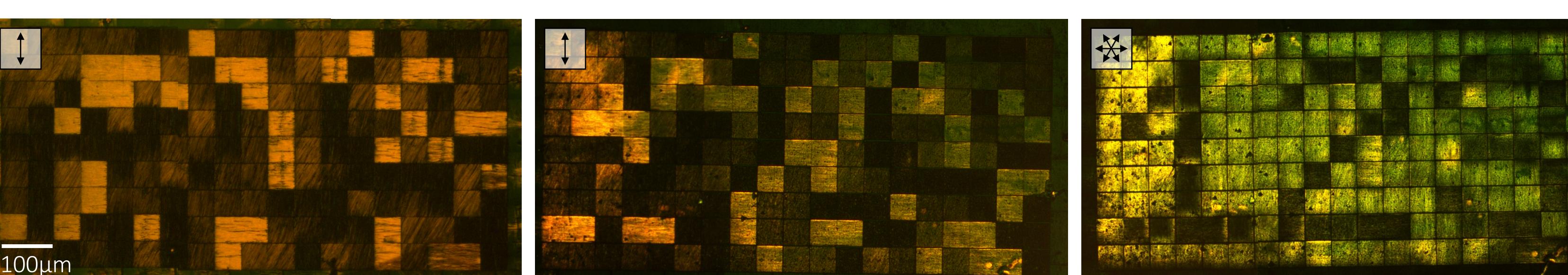


Figure 4. Two aligned, complementary mask “keys” may be overlaid to produce a readable data only when the two-film system is exposed to unpolarized light; unpaired, neither of the masks holds any data.

Core Mono-Substituted NDIs

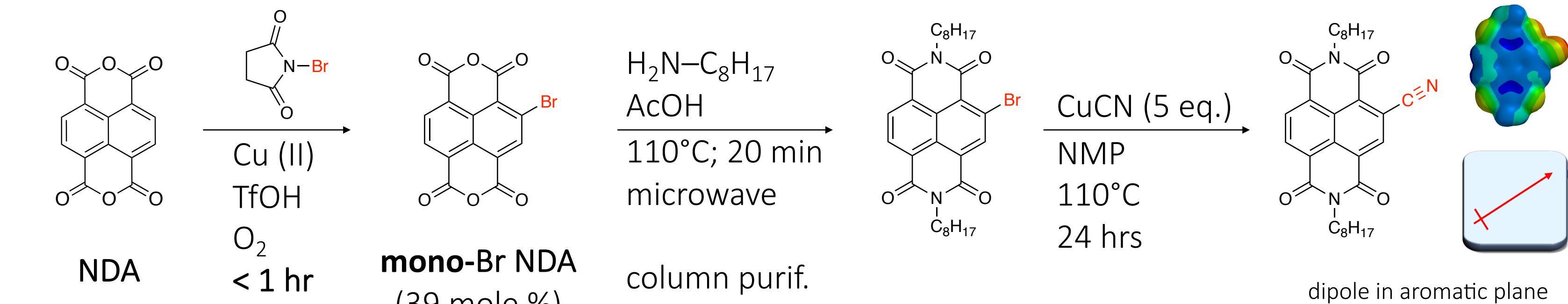


Figure 9. Optimized reaction scheme for selective synthesis of mono-brominated NDI, toward core mono-substituted NDIs (here, achieved by substitution with a cyano functional group).

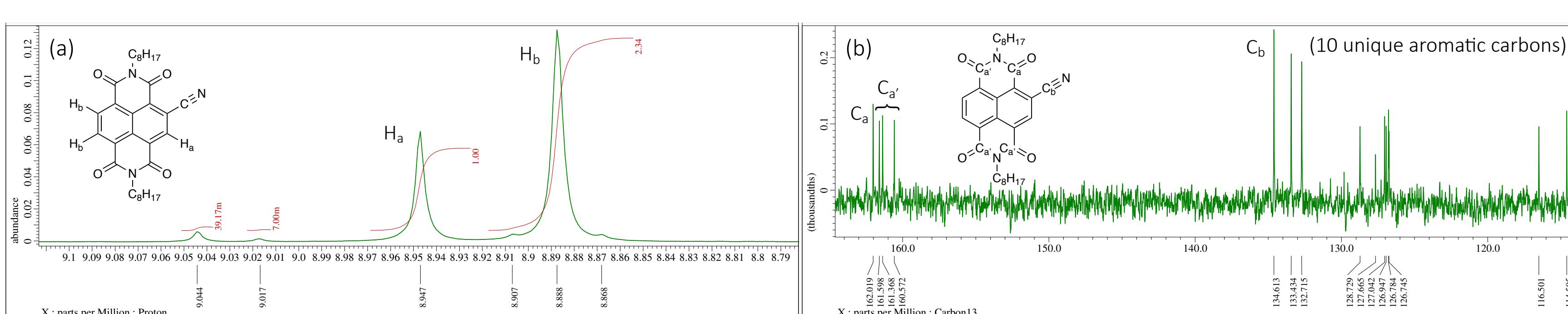


Figure 10. (a) ^1H and (b) ^{13}C NMR spectra of mono-cyano NDI; structure verified by mass spectrometry and IR.

Toward Magneto-Responsive DACLCs

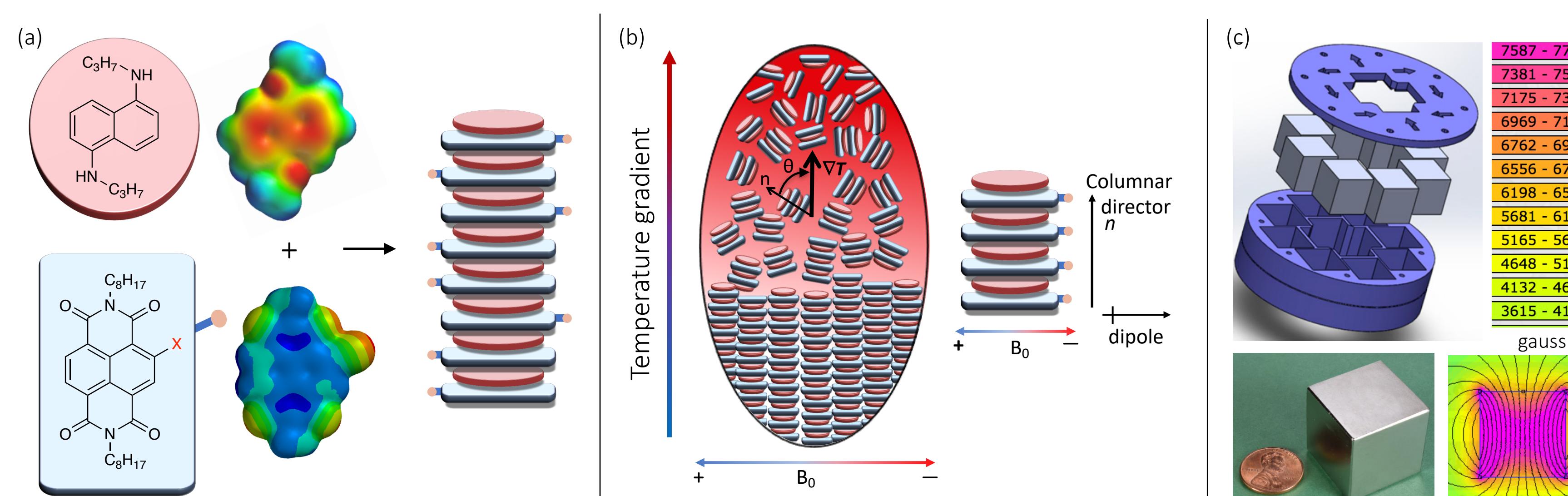


Figure 11. (a) New DACLC materials comprised of mono-substituted NDIs, unlike those comprised of di- or unsubstituted NDIs, will not be structurally uniform through the direction of stacking; (b) however, exposure to an external magnetic field (B_0)—like one produced by the apparatus shown in (c)—may allow for control over this additional degree of freedom. Magneto-responsiveness in DACLCs may complement thermal-gradient alignment as another dimension in which to control molecular orientation, and thereby to store information physically.

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Figure 7. (a) ^1H and (b) ^{13}C NMR spectra of di-cyano NDI; structure verified by mass spectrometry and IR.

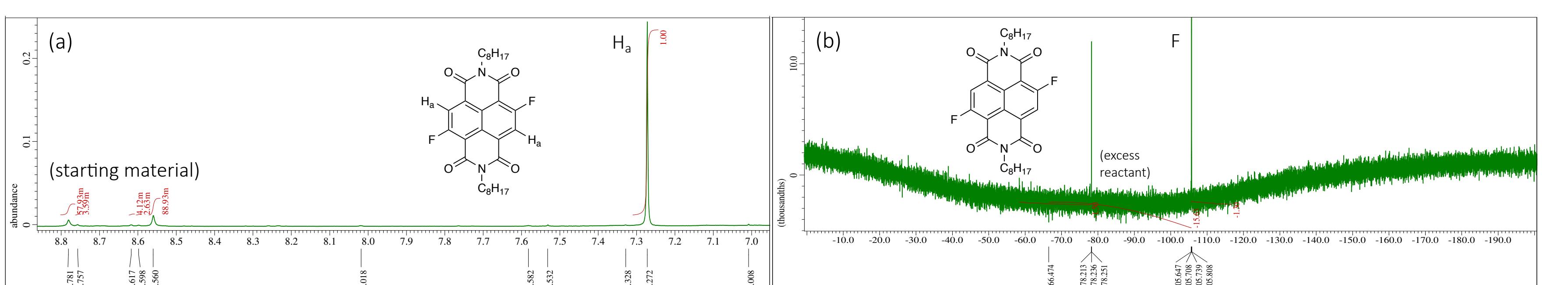


Figure 8. (a) ^1H and (b) ^{19}F NMR spectra of di-fluoro NDI; structure verified by IR spectroscopy.