Conclusions

Thus, the results clearly demonstrated that mixing CN with CA and the strategic use of additives can lead to the successful development of highly efficient CN-based membranes for UF separation of proteins. This makes them promising for use for separation and purification in the pharmaceutical industry.

Acknowledgements

The study was supported by the Russian Science Foundation grant No. 20-79-10064, https://rscf.ru/en/project/20-79-10064/. The experimental work was facilitated by equipment from the Resource Centers for Nanotechnology, Magnetic Resonance, Cryogenic Department, Thermogravimetric and Calorimetric Research Center, Center for Physical Methods of Surface Investigation, Center for Innovative Technologies of Composite Nanomaterials, Chemical Analysis and Materials Research Center, and Center "Nanofabrication of Photoactive Materials (Nanophotonics)" at the St. Petersburg State University.

Determination of the structure of regioisomeric furan-containing naphthofuranes based on 1D and 2D NMR spectroscopy experiments

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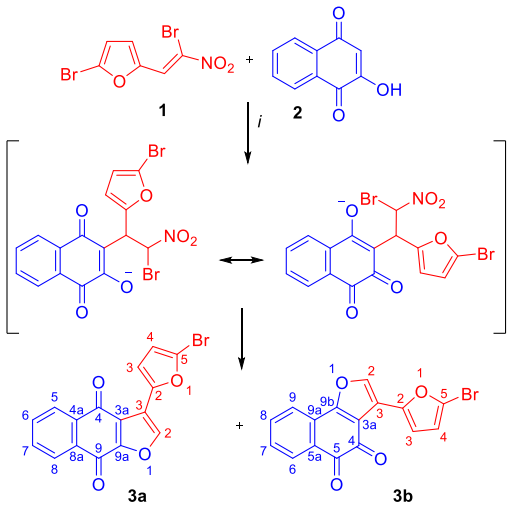
We have previously shown that the interaction of furan-containing *gem*-bromonitroethenes with representatives of cyclic CH-acids leads to the formation of tri- and tetracyclic heterocyclic structures of the dihydrofuran and furan series [1].

The study of the reaction of a representative of furan-containing *gem*-bromonitroethenes – 2-(5-bromofuryl)-1-bromo-1-nitroethene 1 with 2-hydroxynaphthoquinone-1,4 2 showed that the process leads to the formation of a mixture of regioisomeric 3-(5-bromofuran-2-yl)naphtho[2,3-b]furan-4,9-dione 3a and 3-(5-bromofuran-2-yl)naphtho[1,2-b]furan-4,5-dione 3b (ratio 1:1.17 according to the ^{1}H NMR spectrum), which was successfully separated into individual isomers by recrystallization (Scheme 1).

Scheme 1.



i : C_6H_6, Et_3N, 3 h, reflux or MeOH, AcOK, 3d, r.t.

The synthesized 3-(5-bromofuran-2-yl)naphtho[2,3-b]furan-4,9-dione 3a and 3-(5-bromofuran-2-yl)naphtho[1,2-b]furan-4,5-dione 3b can exist as *s-cis*- and *s-trans*-conformers (Fig. 1). The presence of one set of signals in the ^{1}H and ^{13}C NMR spectra of individual substances 3a, b indicates that they are formed by configurationally homogeneous (Fig. 1).

Thus, the aim of this work is to determine the fine structure of 3-(5-bromofuran-2-yl)naphtho[2,3-b]furan-4,9-dione 3a and 3-(5-bromofuran-2-yl)naphtho[1,2-b]furan-4,5-dione 3b by 1D and 2D NMR spectroscopy experiments.

Two doublets at 6.46 and 7.63 ppm (^3J = 3.5 Hz) of the C^3H and C^4H protons of the furan ring, a singlet at 8.14 ppm of the C^2H proton and two multiplets of the protons of the condensed benzene ring in the regions 7.86–7.75 ppm и 8.27–8.19 ppm are observed in the ^1H NMR spectrum of isomer 3a (Fig. 2).

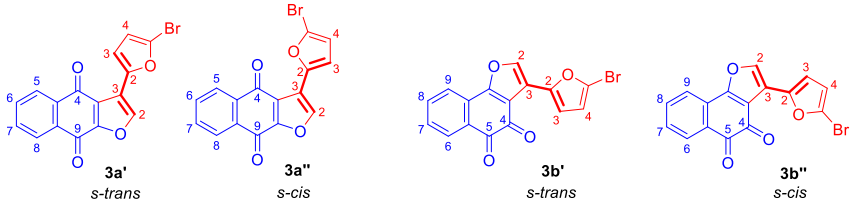


Figure 1. Possible conformational isomers of compounds 3a and 3b.

In the ^1H-^{13}C HMBC spectrum of isomer 3a, cross peaks of the downfield multiplet of the benzene ring in the region of 8.27–8.19 ppm and signals of carbon atoms at 173.63 and 180.20 ppm are observed, which is possibly a consequence of the interaction of the C^5H and C^8H protons with the carbonyl carbon atoms C^4 and C^9, confirming the structure of the regioisomer 3a (Fig. 3).

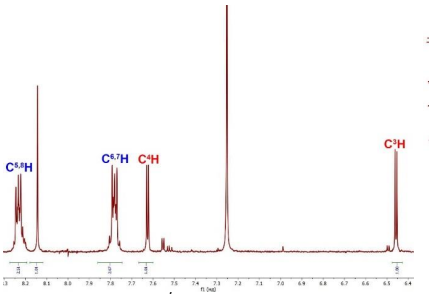


Figure 2. ^1H NMR spectrum of the compound 3a ($CDCl_3$).

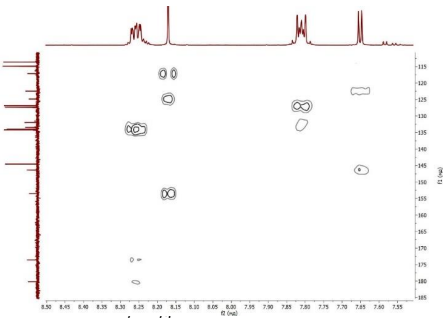


Figure 3. ^1H-^{13}C HMBC NMR spectrum of the compound 3a ($CDCl_3$).

The study of compound 3a by the ^1H-^1H NOESY experiment showed that the C^3H and C^4H protons of the furan ring, as well as C^5H, C^6H, C^7H, C^8H, regularly demonstrate the Nuclear Overhauser Effect, while the C^2H proton does not correlate with the C^3H and C^4H protons of the furan ring, which allows us to assign the *s-trans* configuration to this compound (Fig. 4).

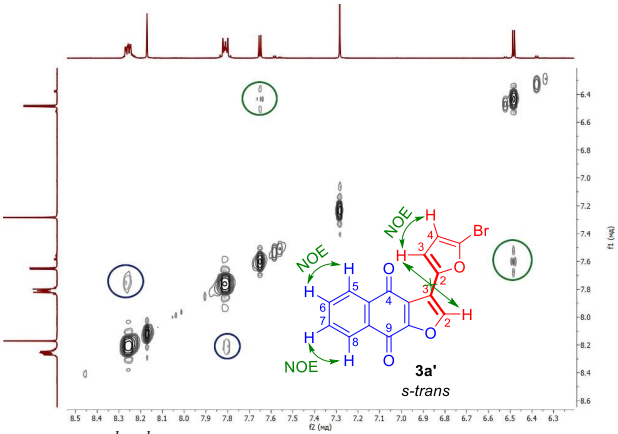


*Figure 4. ^{1}H-^{1}H NOESY spectrum of the compound **3a** ($CDCl_3$)*

Thus, based on the results of the ^{1}H-^{1}H NOESY experiment, the *s-trans* configuration of the obtained 3-(5-bromofuran-2-yl)naphtho[2,3-b]furan-4,9-dione 3a was established. The configuration of 3-(5-bromofuran-2-yl)naphtho[1,2-b]furan-4,5-dione 3b is undergoing further studies.

References

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