Soft Matter, Polymers, Composites

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Strings in homochiral solutions

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Solutions of chiral and achiral trifluoroacetic alkanolamines (TFAAA) in a variety of organic solvents and water were investigated. Homochiral solutions get cured and turn into a gel-like mass on concentrations (10^{-3}-10^{-2}) mol/L which is more than one order less than the percolation threshold. Microscopy techniques revealed an irregular grid of strings which are anisometric structures with diameters about d ~ 1 μm, lengths L ~ 0.5 cm, aspect ratios L/d ~ (10^2-10^4), diameter being constant and strings being rectilinear on lengths >~ (10-100) d which points on the rigidity of the strings [1].

Achiral and racemic solutions with such concentrations don't get cured and in vaporized solutions TFAAA get condensed into isometric granules.

Single strings in solutions were obtained in capillaries which points that the strings are basic objects while the gels are formed due to the presence of the irregular grid of the strings. Such grids establish non-sedimenting mechanical skeletons (calculation shows that a single string should sediment over ~10^3 seconds), Figure 1.

The morphology of the strings is found to be highly dependent on the solvent (dense strings in cyclohexane, rarefied ones in heptane, branching ones in water).

Optical and atomic force microscopy revealed the following structural features. The thinnest (d ~ 0.01-0.1 μm) strings have helical structure [2]. Most of the thicker ones are formed by helically intertwisted thinner strings (Figure 2) which have helical structure themselves (Figure 3). Thus, the superhelicity phenomenon takes place; it is observed on several hierarchy levels. The diameter d and the step length h of a growing helix depend on the individual story of the string; they were observed in the ranges of d ~ (0.01-10) μm and h ~ (0.01-50) μm.

X-ray diffraction techniques revealed a crystalline packing of strings in samples with evaporated solvent. That packing differed with the TFAAA used and didn't depend on the solvent. This points that the identical (for specified TFAAA) long-range order and, perhaps, crystalline structure is formed in the solution, in thin (probably, elementary) strings which, in turn, give rise of the "thick" strings. Solvent molecules are not embedded into the molecular grid of a thin string which can be naturally interpreted as a consequence of solvent molecules being disproportional to the grid size. Because of this such thin strings (consisting of TFAAA molecules only) should be considered as elementary ones. Its grid is based on the complimentary interactions of homochiral TFAAA molecules; its diameters (estimated from the pictures of untwisted "thick" strings) d < 0.1 μm.

Interactions of elementary strings that enable twisting to form thicker ones probably originates from van der Waals forces. Diversity of microscopic strings' morphologies is most likely caused by different ratios of van der Waals forces between elementary strings (the latter depending on the solvent) to elastic forces rising because of superhilicity and corresponding mechanical strain.

1. S.V. Stovbun, Russian Journal of Physical Chemistry B Vol. 5 No. 4 (2011), pp. 546-553
2. S.V. Stovbun, A.M. Zanin, A.A. Skoblin, A.I. Mikhailov, R.G. Kostyanovskii, M.V. Grishin, B.R. Shub, Russian Journal of Physical Chemistry B Vol. 5 No. 6 (2011), pp. 1019-1022
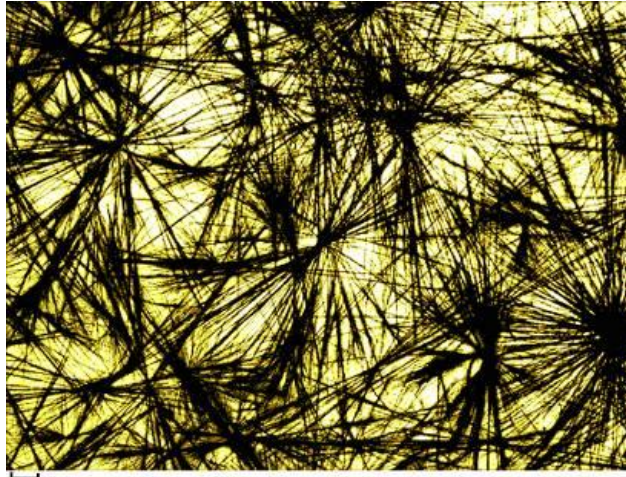
Figure 1. Mechanical skeleton of a gel formed by the strings. Scale bar corresponds to 100 μm.
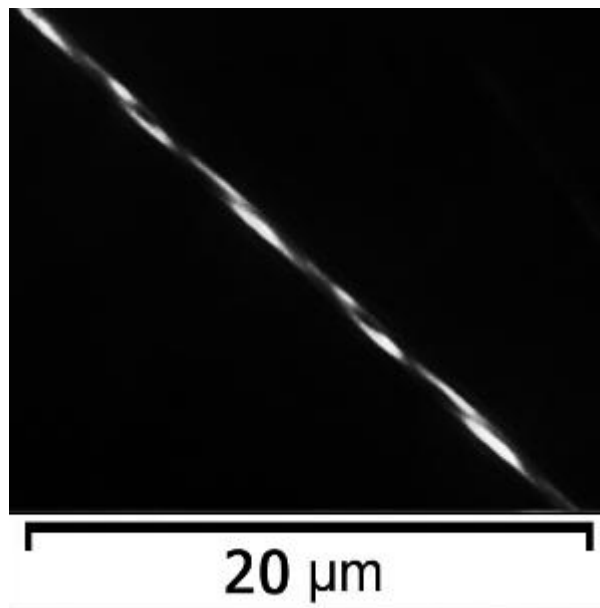

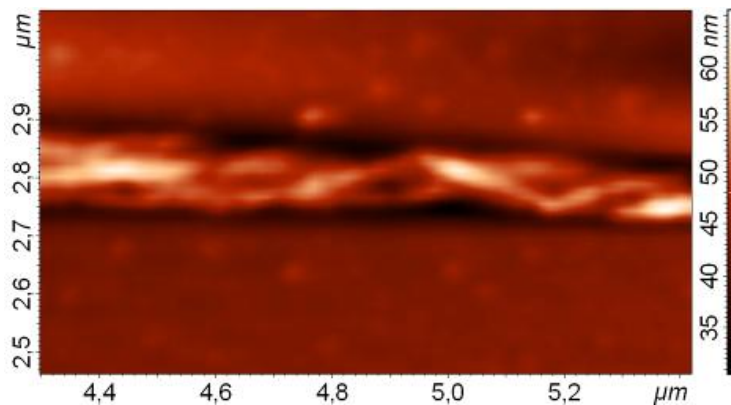**Figure 2.** Helical structure of a solitary string.

Figure 3. A thinner string consisting of intertwisted strings with the diameters of about 50 nm. AFM

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