Uchenye Zapiski Kazanskogo Universiteta. Seriya Estestvennye Nauki 2019 vol.161 N1, pages 42-55

Synthesis and interaction with model DNA of polyaniline and poly[N-(2-hydroxyethyl)aniline]

Khadieva A., Gorbachuk V., Latypov R., Stoikov I.
Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

 The associates of conjugated polymers with biopolymers offer an attractive basis for creating bioelec-trosensors and biointerfaces. Nanostructured materials based on conjugated polymers and biopolymers allow to obtain hybrid electroactive biomaterials for applications in biosensors. Polyaniline and poly[N-(--hydroxyethyl)aniline] have been synthesized by the method of mechanochemical oxidative polymerization. Ammonium persulfate has been used as an oxidant. The obtained polymers have been characterized by 1H NMR, IR, and MALDI mass spectroscopy. The methods of dynamic light scattering and scanning electron microscopy have shown the formation of nano-sized particles: polyaniline forms of particles with the average size of 250 nm (PDI = 0.2); in case of poly[N-(2-hydroxyethyl)aniline], the average size is about 2 μm (PDI = 0.5). The interaction of conjugated polymer dispersions with model DNA from salmon sperm has been investigated by the dynamic light scattering method. The formation of micron-sized associates in the case of polyaniline has been revealed. Lower sizes of the associates have been recorded in the case of poly[N-(2-hydroxyethyl)aniline]. The introduction of hydroxyethyl fragments has resulted in deaggregation of particles forming smaller-sized associates with DNA having the average size of 1.2 μm (PDI=0.3). Such difference in the aggregation of conjugated polymer particles and their associates with DNA is explained by the effect of hydrophilic hydroxyethyl groups that are capable of hydrogen bonding with a biopolymer and allow to achieve higher dispersion stability due to more effective solvation in water.

http://dx.doi.org/10.26907/2542-064X.2019.1.42-55

Keywords

DNA, Mechanochemical oxidative polymerization, Polyaniline, Poly[(N-2-hydroxyethyl)aniline]

References

[1] Fattahi P., Yang G., Kim G., Abidian M.R. A review of organic and inorganic biomaterials for neural interfaces. Adv. Mater., 2014, vol. 26, no. 12, pp. 1846–1885. doi: 10.1002/adma.201304496.

[2] Green R.A., Lovell N.H., Wallace G.G., Poole-Warren L.A. Conducting polymers for neural interfaces: Challenges in developing an effective long-term implant. Biomaterials, 2008, vol. 29, nos. 24–25, pp. 3393–3399. doi: 10.1016/j.biomaterials.2008.04.047.

[3] Gerard M., Chaubey A., Malhota B.D. Application of conducting polymers to biosensors. Biosens. Bioelectron., 2002. vol. 17, no. 5, pp. 345–359. doi: 10.1016/S0956-5663(01)00312-8.

[4] de Lima S.V., de Oliveira H.P., Andrade C.A., de Melo C.P. A dielectric study of interpolymer complexes of polyaniline and DNA. Colloids Surf., A, 2015, vol. 471, pp. 139–147. doi: 10.1016/j.colsurfa.2015.02.002.

[5] Datta B., Schuster G.B., McCook A., Harvey S.C., Zakrzewska K. DNA-directed assembly of polyanilines: Modified cytosine nucleotides transfer sequence programmability to a conjoined polymer. J. Am. Chem. Soc., 2006, vol. 128, no. 45, pp. 14428–14429. doi: 10.1021/ja0648413.

[6] Budnikov H.C., Evtugyn G.A., Porfireva A.V. Electrochemical DNA sensors based on electropolymerized materials. Talanta, 2012, vol. 102, pp. 137–155. doi: 10.1016/j.talanta.2012.07.027.

[7] Zeifman Y.S., Maiboroda I.O., Grischenko Y.V., Morozova O.V., Vasil'eva I.S., Shumakovich G.P., Yaropolov A.I. Enzymatic synthesis of electroconductive biocomposites based on DNA and optically active polyaniline. Appl. Biochem. Microbiol., 2012, vol. 48, no. 2, pp. 145–150. doi: 10.1134/S0003683812020135.

[8] Cobo I., Li M., Sumerlin B.S., Perrier S. Smart hybrid materials by conjugation of responsive polymers to biomacromolecules. Nat. Mater., 2015, vol. 14, no. 2, pp. 143–159. doi: 10.1038/nmat4106.

[9] Bhadra S., Khastgir D., Singha N.K., Lee J.H. Progress in preparation, processing and applications of polyaniline. Prog. Polym. Sci., 2009, vol. 34, no. 8, pp.783–810. doi: 10.1016/j.progpolymsci.2009.04.003.

[10] Huang J. Syntheses and applications of conducting polymer polyaniline nanofibers. Pure Appl. Chem., 2006, vol. 78, no. 1, pp. 15–27. doi: 10.1351/pac200678010015.

[11] García-Gallegos J.C., Vega-Cantú Y.I., Rodríguez-Macías F.J. Fast mechanochemical synthesis of carbon nanotube-polyaniline hybrid materials. J. Mater. Res., 2018, vol. 33, no. 10, pp. 1486–1495. doi: 10.1557/jmr.2018.56.

[12] Heydari M., Najafi Moghadam P., Fareghi A.R., Bahram M., Movagharnezhad N. Synthesis of water-soluble conductive copolymer based on polyaniline. Polym. Adv. Technol., 2015, vol. 26, no. 3, pp. 250–254. doi: 10.1002/pat.3449.