Russian Journal of Electrochemistry 2017 vol.53 N1, pages 25-38

Methylviologen-mediated electrochemical synthesis of silver nanoparticles via the reduction of AgCl nanospheres stabilized by cetyltrimethylammonium chloride

Nasretdinova G., Fazleeva R., Osin Y., Gubaidullin A., Yanilkin V.
Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

© 2017, Pleiades Publishing, Ltd.Efficient synthesis of silver nanoparticles stabilized by cetyltrimethylammonium cations (Ag@CTA+) is carried out in aqueous medium by methylviologen-mediated electroreduction of silver chloride nanospheres stabilized by surface-active CTA+ cations (AgCl@CTA+, diameter ~330 nm), on a glassy carbon electrode at potentials of the MV2+/MV•+ redox couple. The nanospheres AgCl@CTA+ can be reduced immediately on the electrode at a low rate and the resulting metal is deposited on the electrode. In the mediated reduction, the metal is not deposited on the cathode but the quantitative reduction of AgCl to Ag@CTA+ nanoparticles proceeds completely in solution volume at the theoretical charge. In aqueous solution, the nanoparticles are positively charged (electrokinetic (zeta) potential is +74.6 mV), their characteristic absorption maximum is at 423 nm and the average hydrodynamic diameter is 77 nm. Isolated Ag@CTACl nanoparticles have the size of 39 ± 15 nm. The preferential form of metal nanoparticles is sphere with the diameter of 34 ± 24 nm; nanorods are also obtained in small amounts (4%); the average size of metal grains is 8–16 nm.

http://dx.doi.org/10.1134/S1023193517010098

Keywords

cetyltrimethylammonium chloride, electrosynthesis, mediator, methylviologen, nanoparticles, nanorod, nanosphere, reduction, silver, silver chloride, stabilizer

References

[1] Pomogailo, A.D., Rozenberg, A.S., and Uflyand, I.E., Nanochastitsy metallov v polimerakh (Metal Nanoparticles in Polymers), Moscow: Khimiya, 2000.

[2] Roldugin, V.I., Russ. Chem. Rev., 2000, vol. 69, p. 821.

[3] Daniel, M.C. and Astruc, D., Chem. Rev., 2004, vol. 104, p. 293.

[4] Suzdalev, I.P., Nanotekhnologiya: Fiziko-khimiya nanoklasterov, nanostruktur i nanomaterialov (Nanotechnology: Physical Chemistry of Nanoclusters, Nanostructures, and Nanomaterials), 2nd Ed., Librokom, 2009.

[5] Volkov, V.V., Kravchenko, T.A., and Roldugin, V.I., Russ. Chem. Rev., 2013, vol. 82, p. 465.

[6] Dykman, L.A., Bogatyrev, V.A., Shchegolev, S.Yu., and Khlebtsov, N.G., Zolotye nanochastitsy. Sintez, svoistva, biomeditsinskoe primenenie (Gold Nanoparticles. Synthesis, Properties, and Applications in Biomedicine), Moscow: Nauka, 2008.

[7] Kharisov, B.I., Kharissova, O.V., and Ortiz-Méndez, U., Handbook of Less-Common Nanostructures, CRC Press, Taylor Francis Group, 2012.

[8] Rodrigues-Sanchez, L., Blanko, M.L., and Lopez-Quintela, M.A., J. Phys. Chem., 2000, vol. 104, p. 9683.

[9] Yin, B., Ma, H., Wang, S., and Chen, S., J. Phys. Chem. B, 2003, vol. 107, p. 8898.

[10] Saez, V. and Mason, T.J., Molecules, 2009, vol. 14, p. 4284.

[11] Zhu, J., Liu, S., Palchik, O., Koltypin, Y., and Gedanken, A., Langmuir, 2000, vol. 16, p. 6396.

[12] Reisse, J., Caulier, T., Deckerkheer, C., Fabre, O., Vandercammen, J., Delplancke, J.L., and Winand, R., Ultrason. Sonochem., 1996, vol. 3, p. S147.

[13] Reetz, M.T. and Helbig, W., J. Am. Chem. Soc., 1994, vol. 116, p. 7401.

[14] Becker, J.A., Schäfer, R., Festag, R., Ruland, W., Wendorff, J.H., Pebler, J., Quaiser, S.A., Helbig, W., and Reetz, M.T., J. Chem. Phys., 1995, vol. 103, p. 2520.

[15] Reetz, M.T., Quaiser, S.A., and Merk, C., Chem. Ber., 1996, vol. 129, p. 741.

[16] Reetz, M.T., Helbig, W., Quaiser, S.A., Stimming, U., Breuer, N., and Vogel, R., Science, 1995, vol. 267, p. 367.

[17] Reetz, M.T., Winter, M., Breinbauer, R., Thurn-Albrecht, T., and Vogel, W., Chem.- Eur. J., 2001, vol. 7, p. 1084.

[18] Reetz, M.T., Helbig, W., and Quaiser, S.A., Chem. Mater., 1995, vol. 7, p. 2227.

[19] Li, Y., Qiang, Q., Zheng, X., and Wang, Z., Electrochem. Commun., 2015, vol. 58, p. 41.

[20] Vilar-Vidal, N., Blanco, M.C., López-Quintela, M.A., Rivas, J., and Serra, C., J. Phys. Chem. C, 2010, vol. 114, p. 15924.

[21] Yu, Y.-Y., Chang, S.-S., Lee, C.-L., and Wang, C.R.C., J. Phys. Chem. B, 1997, vol. 101, p. 6661.

[22] Mohamed, M.B., Wang, Z.L., and El-Sayed, M.A., J. Phys. Chem. A, 1999, vol. 103, p. 10255.

[23] Yanilkin, V.V., Nasybullina, G.R., Ziganshina, A.Yu., Nizamiev, I.R., Kadirov, M.K., Korshin, D.E., and Konovalov, A.I., Mendeleev Commun., 2014, vol. 24, p. 108.

[24] Yanilkin, V.V., Nasybullina, G.R., Sultanova, E.D., Ziganshina, A.Yu., and Konovalov, A.I., Russ. Chem. Bull., 2014, vol. 63, p. 1409.

[25] Yanilkin, V.V., Nastapova, N.V., Nasretdinova, G.R., Mukhitova, R.K., Ziganshina, A.Yu., Nizameev, I.R., and Kadirov, M.K., Russ. J. Electrochem., 2015, vol. 51, p. 951.

[26] Fedorenko, S., Jilkin, M., Nastapova, N., Yanilkin, V., Bochkova, O., Buriliov, V., Nizameev, I., Nasretdinova, G., Kadirov, M., Mustafina, A., and Budnikova, Y., Colloids Surf. A, 2015, vol. 486, p. 185.

[27] Yanilkin, V.V., Nastapova, N.V., Sultanova, E.D., Nasretdinova, G.R., Mukhitova, R.K., Ziganshina, A.Yu., Nizameev, I.R., and Kadirov, M.K., Russ. Chem. Bull., 2016, vol. 65, p. 125.

[28] Nasretdinova, G.R., Fazleeva, R.R., Mukhitova, R.K., Nizameev, I.R., Kadirov, M.K., Ziganshina, A.Yu., and Yanilkin, V.V., Electrochem. Commun., 2015, vol. 50, p. 69.

[29] Nasretdinova, G.R., Fazleeva, R.R., Mukhitova, R.K., Nizameev, I.R., Kadirov, M.K., Ziganshina, A.Yu., and Yanilkin, V.V., Russ. J. Electrochem., 2015, vol. 51, p. 1029.

[30] Yanilkin, V.V., Nastapova, N.V., Nasretdinova, G.R., Fazleeva, R.R., and Osin, Y.N., Electrochem. Commun., 2015, vol. 59, p. 60.

[31] Yanilkin, V.V., Nasretdinova, G.R., Osin, Y.N., and Salnikov, V.V., Electrochim. Acta, 2015, vol. 168, p. 82.

[32] Yanilkin, V.V., Nastapova, N.V., Nasretdinova, G.R., Fedorenko, S.V., Jilkin, M., Mustafina, A.R., Gubaidullin, A.T., and Osin, Y.N., RSC Adv., 2016, vol. 6, p. 1851.

[33] Shen, Y., Chen, P., Xiao, D., Chen, Ch., Zhu, M., Li, T., Ma, W., and Liu, M., Langmuir, 2015, vol. 31, p. 602.

[34] Krutyakov, Yu.A., Kudrinskii, A.A., Olenin, A.Yu., and Lisichkin, G.V., Russ. Chem. Rev., 2008, vol. 77, p. 233.