

Polymer Coating of Quantum Dots for Excellent Colloidal Stability

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Method Article

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Abstract

In this protocol, a facile procedure for the transfer of quantum dots or different nanoparticles from organic synthesis into aqueous solution is described. Therefore, in the first step, poly(isobutylene maleic anhydride) is modified with hydrophobic side chains via amide bond formation. In the second step, this polymer is mixed with the nanoparticles and wrapped around them. The idea is let the side chains of the polymer intercalate with the inorganic ligands of the nanoparticles, and that the backbone of the polymer which is multifold charges due to the carboxylic groups leads to excellent water solubility. The nanoparticles are finally soluble in buffer solution and cleaned by gel electrophoresis or size exclusion chromatography. Additional functionalization of these nanoobjects is possible via amide bond formation.

Reagents

Tetrahydrofurane (anhydrous), chloroform (anhydrous), poly(isobutylene-*alt*-maleic anhydride) (Mw ≈ 6000 g mol⁻¹, Aldrich, which corresponds to about 39 monomer units per polymer), dodecylamine (Sigma), methoxy-PEG-amine (Mw=5000 g mol⁻¹ from Rapp Polymere or Mw=750 g mol⁻¹ from Fluka) biotin-PEG-amine Mw= 5000 g mol⁻¹ from Rapp Polymere or Mw= 720 g mol⁻¹ from Sigma, aminophenyl β-D-galactopyranoside (Sigma) and fluorescein amine (Aldrich), are used without further purification.

Equipment

Size exclusion chromatography is conducted on an Agilent 1100 HPLC system with a Sephacryl S-300 HR column. Therefore, the mobile phase chosen is 150 mM NaCl in 50 mM sodium borate at pH 9.0

Procedure

I. Design of the polymer
1. Poly(isobutylene-*alt*-maleic anhydride) is vigorously mixed with dodecylamine in 100 mL tetrahydrofurane, so that the amount of added dodecylamine molecules is sufficient to react with 75% of the maleic anhydride units.
2. The cloudy product is heated for several hours (60 °C) and thereby becomes transparent.
3. The solvent is evaporated (e.g. by means of a rotary evaporator) and redissolved in anhydrous chloroform.
4. If a further functionality (such as better solubility at high salt concentrations, biotinylation or fluorescence) of the polymer is desired, an appropriate amount of the respective amino group equipped molecules, such as methoxy-PEG-amine (Mw=5000 g mol⁻¹ or Mw=750 g mol⁻¹) dissolved in chloroform, biotin-PEG-amine (Mw= 5000 g mol⁻¹ or Mw= 720 g mol⁻¹) dissolved in chloroform or THF, aminophenyl β-D-galactopyranoside dissolved in THF, or fluorescein amine dissolved in THF are added dropwise into the diluted polymer solution. Therefore, the amount of added molecules is chosen so that 0.25% to 4% of the maleic anhydride rings of the polymer backbone can react with them.
5. The reaction mixture is stirred overnight.
6. The solvent is evaporated under reduced pressure. Finally the product is re-dissolved in fresh anhydrous chloroform.
II. Polymer coating of the nanoparticles
1. The polymer solution in chloroform is

mixed with the solution of hydrophobic ligand stabilized nanoparticles in chloroform. Therefore, 100 monomer units of the polymer per nm^2 of the nanoparticle surface are inserted. **2.** After 30 min, the solvent is removed under reduced pressure (_e.g._ by means of a rotary evaporator). The thin solid film forms. **3.** The product is dissolved in alkaline sodium borate buffer (SBB) solution at pH 12. **4.** The solvent is exchanged with a buffer of moderate pH, such as SBB at pH 9. This is performed by twice repeatedly diluting and reconcentrating the solution by means of a centrifuge filter. **5.** Residual polymer is removed by size exclusion chromatography and/or gel electrophoresis.

References

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