Polyelectrolytes with sulfonic acid groups useful in the synthesis and stabilization of Au and Ag nanoparticles

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ABSTRACT
Two novel polyelectrolytes were obtained by chemical modification of poly(4-acryloyloxybenzaldehyde) using o- and p-aminophenylsulfonic acid, the characterization shows a chemical modification of 24.38 and 63.33%, respectively. The study shows that the polyelectrolyte with sulfonic acid in para position reduces metal ions more rapidly than polyelectrolyte in ortho position. The obtained nanoparticles of Au and Ag were characterized by ultraviolet–visible absorption spectroscopy (UV–vis) and transmission electron microscopy. The results showed that these ionic polymers are not only capable of reducing gold and silver ions, but also can stabilize the nanoparticles in the colloidal solutions. With these polymers, the process of metallic ions reduction is very slow and they lead to the production of Au and Ag nanoparticles with quasi-spherical shapes which are stable in colloidal solutions for several months. The advantage of the method used here is that the reduction can be realized in water at room temperature.

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Introduction
Polyelectrolytes are an important group of materials due to their wide variety of applications. The polyelectrolytes have found uses in a wide number of technical applications. These include ultrafiltration,[1–3] paper-making, wastewater treatment,[4–6] food industry,[7–9] biomaterials,[10–16] fuel cells[17–23] and nanotechnology,[24–27] just to mention a few. In all these application, the ionic groups or the ionic exchange process of polyelectrolytes is very important.

Many studies have been published the synthesis and characterization of polyelectrolytes with anionic, cationic groups, or both covalently bonded.[28,29] These include experimental studies of mechanism and reaction conditions, physicochemical properties and design of chemical structure. The design of chemical structure of polyelectrolytes includes the appropriate selection of the kind of ionic group in the polymer structure. The cationic polyelectrolytes generally have in their structures basic groups such as amino, phosphonium, sulfonium, boronium, imidazolium, or pyridinium.[29] While the anionic polyelectrolytes have acid groups like carboxylates, sulfates, sulfonates, phosphates, phosphonates, and arsenates.[29] Some polyelectrolytes with arsenic,[24] phosphonic,[30] or sulfonic[31] acid groups have been used successfully in nanotechnology field mainly for the formation of metallic nanoparticles. The metallic nanostructures have been of considerable interest because of their potential applications in medicine, optics, photonics, electronics, catalysis, and magnetism with better performance than their bulk counterparts.[32] However, the applications of the metal nanoparticles depend mainly on their size, shape, and composition.[33–35] The chemical synthesis of metal nanoparticles generally involves the reduction of metallic ions using toxic reducing agents such as sodium borohydride or hydrazine.[36] Nevertheless, recently there has been an increase in the use of polyelectrolytes as reducing agents and at the same time as stabilizers of metallic nanoparticles.[37–39] On the other hand, a crucial aspect on synthesis of nanomaterials is the stabilization to avoid coalescence; stabilization which avoids the aggregation or coagulation phenomena; stabilization can be carried out by steric or electrostatic effects.[40] An advantage of the ionic polymers or polyelectrolytes is that they can stabilize nanoparticles through both effects. In our previous work, we reported the synthesis of polyelectrolytes containing the arsenic acid group (–As(OH)2), able of reduce gold and silver ions and stabilized of Au and Ag nanoparticles. According to the above-described background, in this paper, we report the design, syntheses, and
characterization of the two new polyelectrolytes with sulfonic acid moiety useful for the synthesis and stabilization of Au and Ag nanoparticles.

### Experimental section

#### Materials and instruments

Acryloyl chloride, triethylamine, 2,2′-azobisisobutyronitrile (AIBN), hexachlorocyclophosphazene o-aminophenylsulfonic acid, p-aminophenylsulfonic acid, 4-hydroxybenzaldehyde, dimethylsulfoxide, methanesulfonic acid, hydrochloric acid, HAuCl4·3H2O, and AgNO3 were purchase from Sigma-Aldrich Company and were used without previous purification. N,N′-dimethylformamide (DMF) was distilled over KOH, tetrahydrofuran (THF) were distilled and dried over metallic sodium under argon atmosphere and potassium carbonate was activated by heating at 200 °C for two hours. Nuclear magnetic resonance (NMR) spectra were recorded on a Varian NMR 400 MHz spectrometer. Tetramethylsilane was used as an internal reference, and the samples were prepared with CDCl3, D2O, or DMSO-d6 as solvents. FT-IR spectra were carried out on a Perkin-Elmer spectrophotometer Frontier with a spectral resolution of 4 cm⁻¹, samples were prepared as pellets with anhydrous KBr. Average molecular weight of the polymer were determined by static light scattering measurement using an ALV-500 digital correlator system (Langen-Gmbh, Germany) fitted with a temperature controller set at 25 ± 0.1 °C. For light scattering measurement, sample of poly4-ABZ polymer was dissolved in DMF, in three different concentrations: 22, 25, and 29 mg/cm³. A vertically polarized argon laser (30 mW, λo = 632 nm) was used as excitation source. The intensity of the scattered light was measured at an angle of 90°. The reduced elastic scattering I(q)/Kc with K = 4π²n²/λ² (dc/dc) (dc²/2c²) of the sample was measured, where n is the average molecular weight of the polymer solutions (d/dc) was maintained with stirring for 24 h, the solid formed was eliminated by filtration. THF was evaporated under reduced pressure, and a yellow liquid was obtained. The crude product was purified by chromatographic column of silica gel using CH2Cl2 as eluent. The monomer 4-acryloyloxy benzaldehyde was recovered in the first fraction, CH2Cl2 was evaporated, the yellow liquid was obtained and it was dried under high vacuum. Yield: 72%. 1H-NMR (400 MHz, CDCl3) δ:6.80 (1H, =CH; cis). A Zimm plot was constructed to extract the average molecular weight using the following equation:

\[
Kc/R_0 = (1/M) + 2Ac
\]

where M is the average molecular weight and A is the second virial coefficient. The average molecular weight was obtained from the Y-axis intercept of the Kc/R⁰ vs. c plot at c = 0.

UV–vis spectra were recorded with a Perkin–Elmer (model Lambda 2S) UV–vis spectrophotometer using 10-mm optical path length quartz cuvette. The size and shape of the nanoparticles were analyzed by transmission electron microscopy (TEM), the TEM images were taken with a JEOL (model JEM 2100) transmission electron microscope operating at 200 KV. The samples for TEM were made by depositing the colloidal solution on carbon-coated copper grids and dried in vacuum, size measurements were performed manually on TEM images.

### Synthesis of polyelectrolytes with sulfonic acid groups

Polyelectrolytes with sulfonic acid moiety were synthesized by a three-step process, first the 4-acryloyloxy benzaldehyde monomer was prepared, second the 4-acryloyloxy benzaldehyde was polymerized by free radical, and finally the poly(4-acryloyloxy benzaldehyde) was chemically modified by the condensation reaction with o- or p-aminophenylsulfonic acids, Figure 1.

#### Synthesis of 4-acryloyloxy benzaldehyde (4-ABz)

The 4-acryloyloxybenzaldehyde monomer was synthesized by a nucleophilic acyl substitution reaction between the 4-hydroxybenzaldehyde and acryloyl chloride. Into a round-bottom flask, previously degassed, 5 g (20.47 mmol) of 4-hydroxybenzaldehyde was dissolved in 70 cm³ of anhydrous THF. The system was placed in an ice bath with magnetic stirring, and simultaneously 3 cm³ (21.50 mmol) of triethylamine and 2 cm³ (24.72 mmol) of acryloyl chloride were added dropwise under argon atmosphere. The mixture was stirred at 5 °C during 1 h, then the system was heated at 70 °C for 2 h, and subsequently was cooled until room temperature. Finally, the reaction mixture was maintained with stirring for 24 h. The solid formed was eliminated by filtration. THF was evaporated under reduced pressure, and a yellow liquid was obtained. The crude product was purified by chromatographic column of silica gel using CH2Cl2 as eluent. The monomer 4-acryloyloxy benzaldehyde was recovered in the first fraction, CH2Cl2 was evaporated, the yellow liquid was obtained and it was dried under high vacuum. Yield: 72%. 1H-NMR (400 MHz, CDCl3) δ:6.80 (1H, =CH; cis). 13C NMR (100 MHz, CDCl3) δ (ppm): 190.77 (C=O); 166.59 (C=O); 155.06 (Ar); 133.82 (Ar); 129.10 (CH=CH2); 131.03 (Ar); 127.19 (CH=CH2); 122.15 (Ar). FT-IR (KBr, cm⁻¹): 3100 vC=H (alkene); 1740 vC=O (ester); 1700 vC=O (aldehyde); 1638 vC=C (alkene); 1590, 1500, 1410 vC=C (aromatic); 1190, 1160 vC=O (ester); 985 δ out of plane C–H (alkene); 905 δ out of plane C–H (alkene). Raman
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\[ \text{3072 } \nu_{\text{C–H}} \text{ (alkene); 3047, 3000 } \nu_{\text{Ar–H}}; 1735 \nu_{\text{C=O}} \text{ (ester); 1695 } \nu_{\text{C=O}} \text{ (aldehyde); 1635 } \nu_{\text{C=C}} \text{ (alkene); 1600, 1410 } \nu_{\text{C=C}} \text{ (aromatic); 1207, 1158 } \nu_{\text{C–O}} \text{ (ester).} \]

Poly(4-acryloyloxybenzaldehyde) (Poly4-ABz)

The 4-ABz was polymerized by free radical polymerization in solution. In a test tube, 3 g of 4-acryloyloxy benzaldehyde was dissolved in 1 cm\(^3\) of DMF or toluene, 2% wt. of AIBN were added and the mixture was degassed with argon during 20 min. The tube was sealed and dipped into a water bath at 70 \(^\circ\text{C}\) for 60 min. The mixture was precipitated in water, the solid formed was filtered and dried at 60 \(^\circ\text{C}\) under reduced pressure for 8 h. Yield: 91%.

\[ \text{\(^{1}H\)-RMN (400 MHz, DMSO–d\(_6\)) } \delta \text{ (ppm): 10.65 (s, 0.5H); 9.84 (d, } J=28.8 \text{ Hz, 1H), 8.3–6.8 (m, 6H), 2.98–1.59 (m, 5H).} \]

RMN–\(^{1}H\) (400 MHz, D\(_2\)O–NaOH) \(\delta\) (ppm): 8.92 (s, 1H), 7.23 (d, \(J=8.4 \text{ Hz, 3H}), 6.16 (d, J=7.6 \text{ Hz, 3H}), 1.73–1.02 (m, 5H). \]

FT–IR (KBr, cm\(^{-1}\)):

- 3450 \(\nu_{\text{OH}}, 2925 \nu_{\text{C–H}} \text{ (alkane); 1765 } \nu_{\text{C=O}} \text{ (carboxylic acid); 1735 } \nu_{\text{C=O}} \text{ (ester); 1690 } \nu_{\text{C=O}} \text{ (aldehyde); 1600, 1500 } \nu_{\text{C=C}} \) (aromatic); 1207 \(\nu_{\text{C–O}} \text{ (ester).} \]

Raman (cm\(^{-1}\)):

- 1700 \(\nu_{\text{C=O}}\); 1207, 1159 \(\nu_{\text{C–C}}\) – O. Light scattering measurements offered M\(_w\) = 41 216 g/mol for poly4ABz.

\[ \text{Figure 1. Synthesis of polyelectrolytes with sulfonic acid groups.} \]

\[ \text{Poly(4-acryloyloxybenzaldehyde) (Poly4-ABz)} \]

The 4-ABz was polymerized by free radical polymerization in solution. In a test tube, 3 g of 4-acryloyloxy benzaldehyde was dissolved in 1 cm\(^3\) of DMF or toluene, 2% wt. of AIBN were added and the mixture was degassed with argon during 20 min. The tube was sealed and dipped into a water bath at 70 \(^\circ\text{C}\) for 60 min. The mixture was precipitated in water, the solid formed was filtered and dried at 60 \(^\circ\text{C}\) under reduced pressure for 8 h. Yield: 91%.

\[ \text{Chemical modification of poly(4-acryloyloxybenzaldehyde)} \]

The polymer I was chemically modified by the condensation reaction of aldehyde groups with \(p\)-aminophenylsulfonic acid or \(o\)-aminophenylsulfonic acid, respectively. The reaction conditions involves different weight ratio of \(o\)- or \(p\)-aminosulfonic acids and poly(4-acryloyloxy benzaldehyde) (2:1, 1:1, and 1:2 wt.), respectively. The optimal condition of reaction is described below.

\[ \text{Chemical modification of poly(4-acryloyloxybenzaldehyde) with p-aminophenylsulfonic acid (Polyelectrolyte I).} \]

Into a round-bottom flask, 500 mg of poly(4-acryloyloxy benzaldehyde), 250 mg of \(p\)-aminophenylsulfonic acid, 27 mg of methanesulfonic acid, and 2 cm\(^3\) of DMSO were mixed and heated at 90 \(^\circ\text{C}\) for 3 h under argon atmosphere.
The formation and growth of the Au and Ag nanoparticles were monitored at different time intervals using UV–vis spectroscopy.

**Results**

The 4-acryloyloxy benzaldehyde monomer was obtained by a nuclophilic acyl substitution, and the monomer was successfully polymerized using a typical free radical polymerization. The structures of the monomer and their homopolymer were confirmed by means of spectros­copy techniques. The Figure 2 shows the FTIR spectrum of the 4-acryloyloxy benzaldehyde monomer (4-ABz), the most important absorption bands that gave evidence of formation of this monomer were the bands associated with ester and alkene groups. The absorption bands at 1740 cm⁻¹ corresponded to stretching absorption bands νC=O, the bands in 1290 and 1190 cm⁻¹ were assigned to νC–O for the ester group, besides the absorption bands at 1635 νC=C were assigned to terminal vinyl group and the bands at 980 and 910 cm⁻¹ were assigned to bending vibration δC–H out of plane of the alkene. The band observed at 1700 cm⁻¹ were attributed to stretching vibration νC=H out of plane of aromatic ring.

Chemical modification of poly(4-acryloyloxybenzaldehyde) with o-aminophenylsulfonic acid (Polyelectrolyte II).

Into a round-bottom flask, 100 mg of poly(4-acryloyloxy benzaldehyde), 50 mg of o-aminophenylsulfonic acid, 20 mg of concentrated HCl, and 2 cm³ of DMSO were heated at 90 °C under argon atmosphere for 40 min. The mixture was precipitated in CH₂Cl₂ and the solid formed was washed with acetone-DMSO (1:1) three times, finally the product was washed with DMF and dried under reduced pressure at 60 °C for 48 h. Chemical modification of the polymer calculated by ICP: 24.38%. FT–IR (KBr, cm⁻¹): 3450 νOH; 2923 νC–H (alkane); 1765 νC=O (carboxylic acid); 1735 νC=O (ester); 1710 νC=O (aldehyde); 1648 νC=N (imine); 1600 and 1500 νC=C (aromatic); 1378 νasymmetric O=S=O; 1206 νC–O (ester); 615 νC–S.

**Preparation of Au and Ag nanoparticles**

All the solutions of metallic salts and polyelectrolytes were prepared with deionized water (18 MO). The solutions of the metallic salts and polyelectrolytes were prepared with a concentration of 1 × 10⁻³ M and 2000 ppm (in 0.04 M NaOH solution), respectively. For the preparation of Au and Ag nanoparticles, 5 cm³ of HAuCl₄ 3H₂O or AgNO₃ solution was added to 5 cm³ of polyelectrolyte solution at room temperature. The solution was under stirring for 5 s and then was maintained in rest, without other reducing agent.

The DMSO was removed by vacuum distillation, the polymer was washed with acetone–DMSO (95:5) several times, and a yellow solid was dried under reduced pressure at 70 °C for 12 h. Chemical modification of the polymer calculated by ICP: 63.33%. FT–IR (KBr, cm⁻¹): 3456 νOH; 2922 νC–H (akane); 1754 νC=O (carboxylic acid); 1736 νC=O (ester); 1700 νC=O (aldehyde); 1665 νC=N (imine); 1600 and 1580 and νC=C (aromatic); 1377 νasymmetric O=S=O; 1224 νC–O (ester); 1170 νsymmetric O=S=O; 615 νC–S.
The 1H-NMR spectrum of 4-acryloyloxybenzaldehyde shows five signals that integrate for eight protons, Figure 3(a). The signals observed at 6.65, 6.34, and 6.30 ppm correspond to the three protons of vinyl group, and their chemical displacements observed are characteristic of the alkene group. The proton of aldehyde group is a singlet at 10 ppm and finally the presence of aromatic protons in the monomer is confirmed by two doublets, localized at 7.74 and 7.33 ppm. The formation of the poly(p-acryloyloxybenzaldehyde) was confirmed by 1H-NMR spectroscopy, the spectrum shows seven broad signals, Figure 3(b). The principal evidence of polymer formation is the disappearance of the signals of vinyl group of the monomer and the subsequent appearance of the protons of saturated hydrocarbon chain of the backbone at 2.82 and 1.75 ppm, which integrate for three protons. The signals corresponding to the aromatic protons were observed in the 6–8.5 ppm interval. At 10.63 and 9.8 ppm were observed two singlets, the singlet at 9.8 ppm was assigned to aldehyde proton while the singlet at 10.63 was assigned to acid proton of carboxylic acid. The proton of carboxylic acid confirms that during the polymerization reaction a quantity of aldehyde groups was oxidized to acid groups. The quantifying of the aldehyde and acid groups was made from 1H-NMR integrals, the study shows 72.2 and 27.8% of each group, respectively. The formation of the acid groups was confirm with other experiment of 1H-NMR, the study was carried out with D₂O as solvent and NaOH was added to the sample; in the spectrum is observed a singlet at 9.11 ppm that was assigned to the aldehyde proton, while the signal at
well known that noble metal nanoparticles exhibit a strong absorption band in the UV–vis region due to surface plasmon resonance (SPr). Figure 4(A) shows the UV–vis spectra of colloidal solution taken at different times intervals after mixing HAuCl4·3H2O aqueous solution with polyelectrolyte I aqueous solution at room temperature. Whereas, the Figures 4(B) and (C) show the molecular structure of the polyelectrolyte I and the pictures of the solutions, respectively. The first evidence of the reduction of Au+++ for the polyelectrolyte I was the change of color observed in the solution. For this polyelectrolyte, the solution that initially was orange acquired a brown color after 5 min of reaction and after practically did not change. The formation of Au nanoparticles using the polyelectrolyte I was evident from the first minutes of reaction, when a band around 569 nm attributed to the SPr of Au nanoparticles was detected. With the increase in the reaction time, the band shifts

10.8 ppm is not observed, because the acid protons have been exchanged with Na+ ions.

The chemical modification of poly(4-acryloyloxybenzaldehyde) with aminophenylsulfonic acids was suitable synthesis route to obtain polyelectrolytes with sulfonic acids moiety in ortho- and para- positions. According with the ICP results, 24.38% of aldehyde groups were converted to imine groups for polyelectrolyte II, while the modification degree for polyelectrolyte I was of 63.35%.

**Synthesis of Au nanoparticles using the polyelectrolytes I and II**

Formation of Au nanoparticles using the polyelectrolytes I and II, which contain carboxylic and sulfonic acid groups bonded covalently to the polymer structure, was monitored in situ for UV–vis absorption spectroscopy, since it is

![Figure 4](image)

**Figure 4.** (A) Temporal evolution of UV–Vis spectra of Au nanoparticles; (B) molecular structure of polyelectrolyte I; and (C) pictures of the solution of polyelectrolyte I and of the colloidal solution of Au nanoparticles stabilized by polyelectrolyte 1 after 24 h.

![Figure 5](image)

**Figure 5.** Typical TEM image of Au nanoparticles obtained with the polyelectrolyte I.
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which have a quasi-spherical shape and average diameter of 5.9 nm.

Same as polyelectrolyte I, the solution of polyelectrolyte II was also able to reduce to gold ions; however, the formation of Au nanoparticles was slower with this polymer. The UV–vis spectra of colloidal solution of Au nanoparticles into polyelectrolyte II, the molecular structure of polyelectrolyte and the picture of the colloidal solution of Au nanoparticles are shown in Figure 6. The absorption spectrum acquired after 5 h revealed a band at around 561 nm, which is due to the interaction of free electrons confined to small Au particles with incident electromagnetic radiation, known as the SPR of the Au nanoparticles. As happened with polymer I, a shift gradual of the plasmon band to lower wavelengths was also detected, from 561 nm (after 5 h) to 543 nm for a time of reaction of 16 days, after this time the position of the band did not change. On the other hand, the intensity of the band increases progressively from 6 h to 16 days, because of the increase in the density of particles in the colloidal solution. After 16 days, the intensity of the band did not change. In this case, the colloidal solution that initially was orange acquired a brown color after 5 min of reaction and after 24 h of reaction, then the color of the solution changes to dark brown. Figure 7 shows a typical TEM image of the nanoparticles obtained with the polyelectrolyte II after 16 days. TEM image revealed the formation of quasi-spherical Au nanoparticles of size between 2 and 9 nm. The size of Au nanoparticles was controlled because of their high molecular weight as well as the presence of sulfonic acid groups in polyelectrolytes. Also, low concentrations of polyelectrolytes are required to control the size of Au nanoparticles.

The results obtained from UV–vis spectroscopy and TEM clearly demonstrate that the two polyelectrolytes are able to reduce gold ions and can stabilize Au nanoparticles in

Figure 6. (A) Temporal evolution of UV–Vis spectra of Au nanoparticles prepared with the polyelectrolyte II; (B) molecular structure of polyelectrolyte II; and (C) picture of the colloidal solution Au nanoparticles stabilized by polyelectrolyte II after 24 h.

Figure 7. Typical TEM image of Au nanoparticles in the polyelectrolyte II.

gradually from its starting point to 538 nm for a time of reaction of three days, whereas its intensity increased. The gradual shift to lower wavelength can be associated with the decrease in the average size of the particles and the increase in the intensity of the band is due to the increase in the amount of particles formed, which reaches a value maximum about four days. After three days, the characteristics of the absorption band practically did not change indicates that the nanoparticles are stable in the solution. The colloidal solution stays stable during several months and no precipitation is observed.

Figure 5 shows a typical TEM image of Au nanoparticles stabilized by the polyelectrolyte I in aqueous solution, after four days of reaction. TEM images revealed the formation of Au nanoparticles with size in the range from 3 to 9 nm,
aqueous solutions at room temperature; and that with the polyelectrolyte II both processes are slower. Both polyelectrolytes contain imines groups and also carboxylic and sulfonic acid groups which serve as reducing and stabilizing agents, also these polyelectrolytes combines both steric and electrostatic stabilization effects and can therefore stabilize colloidal metal nanoparticles much better than other polymers or surfactants. The polyelectrolytes I and II have a similar structure but show a difference in the position of the sulfonic groups into the polymer structure, such difference conduce to a behavior slightly different in the process of reduction of gold ions and in the stabilization of Au nanoparticles.

**Synthesis of Ag nanoparticles using the polyelectrolytes I and II**

Formation of the Ag nanoparticles using the polyelectrolytes I was monitored by UV–vis absorption spectroscopy. Figure 8 shows the time evolution of UV–vis absorption spectra after addition of AgNO₃ solution into the polyelectrolyte I solution at room temperature. Formation of Ag nanoparticles was confirmed by the presence of the

**Figure 8.** Temporal evolution of UV–vis absorption spectra of Ag nanoparticles in the colloidal solution of polyelectrolyte I.

**Figure 9.** TEM images of Ag nanoparticles synthesized with the polyelectrolyte I.
characteristic SPR band in the UV–vis spectra, such band was localized at around 442 nm until 15 days of reaction. This indicates that the process of reduction of the Ag⁺ ions using the polyelectrolyte 1 is very slow. The intensity of the SPR band increased systematically with the increase in reaction time to reach a maximum after about 42 days. Thereafter, the intensity of the SPR band did not change.

Figure 9 shows some images of TEM of the nanoparticles in the solution after 42 days of reaction, when no longer considerable variations of the UV–vis spectra were registered. In the TEM images, we can observe that the particles are irregular shapes with size between 17 and 42 nm, the average size of the particles is 30 nm.

Figure 10 shows the time evolution of UV–vis absorption spectra after addition of AgNO₃ solution into the polyelectrolyte II solution at room temperature. In this case, the absorption band corresponding to the SPR of the Ag nanoparticles was observed until 2 month of reaction, indicating that the process of reducing Ag⁺ ions using the polyelectrolyte II is very slow. TEM image of the Ag nanoparticles in the final colloidal solution (see Figure 10) demonstrates that indeed the majority of Ag nanoparticles have size between 5 and 10 nm, and one small portion of particles are in close packed assembly or in aggregation forming big particles.

**Conclusions**

The chemical modification of poly(4-acryloyloxybenzaldehyde) with aminophenylsulfonic acids is an appropriate synthesis route to obtain polyelectrolytes with sulfonic acids moiety. The degree of chemical modification could be controlled with the initial concentration of the aminosulfonic acid. Polyelectrolytes are able to reduce gold and silver ions in aqueous solutions at room temperature, and also the ability of these polymers to protect the Au and Ag nanoparticles permits to obtain stable colloidal solutions for several months. The two polyelectrolytes which are being reported are better for the synthesis and stabilization of Au nanoparticles because they can control their size and shape. The novel acid polyelectrolytes would be very much helpful as reducing and stabilizing agents for the synthesis of other metallic particles.

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