Complex formation of pendant lysine groups-bearing polymers with copper

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Abstract

L-lysinyl acrylamide (LysA) acts as a cation because of the protonation of the pendant primary amino and carboxyl groups, and becomes zwitterion by deprotonation of the carboxyl groups near neutral. In addition, deprotonation of the pendant amino and carboxyl groups at basic condition leads to an anion. Since amino acids form complexes with Cu^{2+}, a random copolymer, poly(2-methacryloxyethyl phosphorylcholine/LysA) (P(MPC/LysA)) forms complexes when the polymer was mixed with Cu^{2+} at pH 7.4. When P(MPC/LysA) and Cu^{2+} mixed so that $[Cu^{2+}]/[NH_2] = 0.5$, complexes became near to sphere. The formation of these complexes was confirmed at pH > 5, and the aggregates collapsed at pH < 3. Since the carboxyl groups of the LysA units are deprotonated at pH > 5, it is important that the carboxyl groups are deprotonated for the complex formation.

1. Introduction

Poly(2-methacryloyloxyethyl phosphorylcholine) (PMPC), a zwitterionic polymer, is biocompatible because it has phosphorylcholine groups that are the same chemical structure as the hydrophilic groups of the phospholipids constituting a cell membrane. Therefore, PMPC has been used as a medical polymer for several decades. Poly(*L*-lysinyl acryamide) (PLysA) containing lysine pendant groups, is a zwitterionic polymer similar as PMPC. PLysA has pendant primary amino and carboxyl groups that can either be protonated or deprotonated in response to pH of the solution. PLysA becomes polycation and polyanion at acidic and basic pH, respectively (Fig. 1a). Besides,

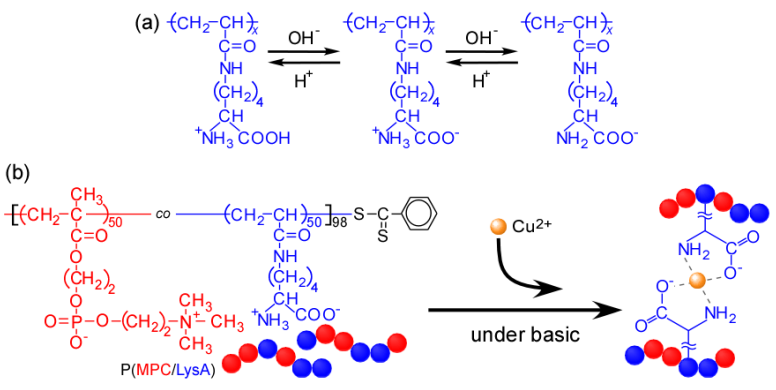

Fig. 1 (a) pH-responsive changes in chemical structure of PLysA and (b) conceptual illustration of Cu^{2+} induced aggregation for P(MPC/LysA).

it is known that PLysA forms complexes with copper ion (Cu^{2+}) when the carboxyl group is deprotonated[1]. Hence, in this study, a random copolymer (P(MPC/LysA)) was prepared and its complex formation with Cu^{2+} was investigated at different pH (Fig. 1b).

2. Experiment

P(MPC/LysA) with degree of polymerization of 100 and 50 % LysA content was prepared via reversible addition-fragmentation chain transfer polymerization. The complex formation was confirmed by dynamic light scattering (DLS) measurements of P(MPC/LysA) solutions with or without Cu^{2+} at different pH. The shape of the complex was also confirmed by small angle X-ray scattering (SAXS) and transmission electron microscopy (TEM) measurements.

3. Results and discussions

P(MPC/LysA) showed bimodal hydrodynamic radius (R_h) distribution consisting unimers (R_h = ca. 10 nm) and aggregates peaks (R_h = ca. 100 nm), suggesting that P(MPC/LysA) coexists as unimers and aggregates in water at pH 7.4 (Fig. 2a). P(MPC/LysA) formed aggregates because of the interpolymer weak interactions. When a half molar amount of Cu^{2+} to the amine group in P(MPC/LysA) was added to the aqueous P(MPC/LysA) solution at pH = 7.4 and 11, the R_h distribution was changed to unimodal with ca. 30 nm (Fig. 2c, d). P(MPC/LysA) formed complexes with Cu^{2+} when the carboxyl group was deprotonated. The complexes are spherical shape by SAXS and TEM measurements. When a half molar amount of Cu^{2+} to the amine group in P(MPC/LysA) was added to the aqueous solution at pH = 3, the R_h distribution was not changed (Fig. 2b). It is suggested that the complexes of P(MPC/LysA) with Cu^{2+} collapsed at acidic conditions because pendant carboxyl groups of LysA units were protonated.

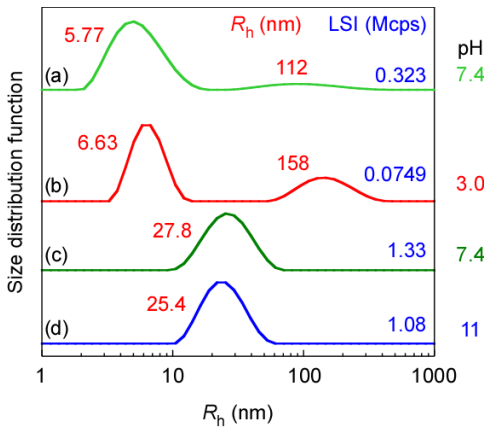

Fig. 2 R_h distributions for (a) P(MPC/LysA) with C_p = 10 g/L at pH 7.4 and mixture of P(MPC/LysA)/ Cu^{2+} ($[Cu^{2+}]/[NH_2]$ = 0.5) with C_p = 1 g/L at pH (b) 3.0, (c) 7.4, and (d) 11 in 0.1 M NaClaq.

4. Conclusions

P(MPC/LysA) showed pH-responsive behavior in water. When P(MPC/LysA) was mixed with Cu^{2+} at pH 7.4, P(MPC/LysA) formed complexes with Cu^{2+}. It is expected that P(MPC/LysA) can be used to remove excess Cu^{2+} from the body.

Reference

1) Banerjee. S, et. al., *Macromol. Rapid Commun*., *34*, 1480-1486 (**2013**).