1. Introduction

Dispersions of solid nanoparticles in liquid phases are widely employed in application areas such as cosmetics, coatings, and catalysis [1]. For these applications, a high stability of colloidal dispersions is required; however, dispersions are often thermodynamically unstable and tend to agglomerate over time. Therefore, in order to extend the utilization time without any loss of performance, an enhancement of the colloidal stability is desired.

The approach followed by this work to enhance the stability of colloidal dispersions is the particle surface functionalization by using so-called “amino-quat-primer” polymers. An amino-quat-primer polymer is a hyperbranched poly(ethylenimine) polymer which contains amino groups and quaternized groups (cf. Figure 1-1,1) [2]. Such polymers strongly adsorb on even slightly negatively charged surfaces by cooperative ionic interactions (cf. Figure 1-1,2). This approach provides two main advantages over a physical modification by low molecular weight compounds with only one ionic group per molecule: The numerous ionic bonds between one macromolecule and the surface cause a highly stable connection and besides, the new generated surface exhibits a high density of functional groups.

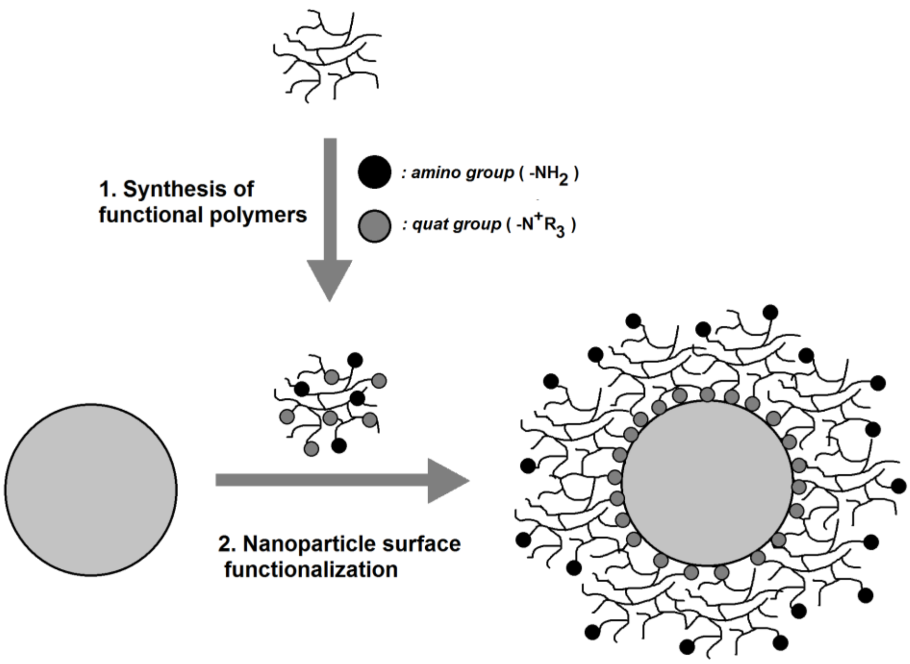

Figure 1-1: Scheme of 1) Synthesis of functional polymers and 2) Nanoparticle surface functionalization

Even though prior studies have revealed the positive effects of amino-quat-primer polymers on the stability of colloidal particles [3,4,5], deeper investigations of the occurring polymer-particle-interactions had not been carried out. To address this gap, in this work a systematic study on the factors influencing the interaction of colloidal particles with amino-quat-primer polymers was performed. To investigate this interaction, five key factors were defined, including: the polymer-particle-ratio, the degree of polymerization and the degree of functionalization of the polymers, the dispersion pH and the salt concentration.

For the present study, colloidal silica was chosen as a model system to investigate dispersion stability, because it exhibits several desired properties, e.g. an easy and precise size control, low manufacturing costs, broad application spectrum, and an inherent stability in aqueous solution without further additives [6].

To achieve the objective of this thesis, firstly, amino-quat-primer polymers were synthesized and characterized; secondly, these polymers were employed to functionalize the surface of silica nanoparticles; and finally, the dispersion stability and the particle surface charge of these produced silica-polymer-dispersions were analyzed.

In Chapter 2 the following relevant literature for this work is reviewed: polyelectrolytes in general and hyperbranched poly(ethylenimine) in particular; silica nanoparticles; the electric double layer - and the DLVO theory; dynamic light scattering and laser-Doppler-velocimetry; the adsorption of charged polyelectrolytes on oppositely charged particles in general, as well as the adsorption of poly(ethylenimine) on silica surfaces in particular.

The experimental data of the synthesis of amino-quat-primer polymers and the preparation of silica-polymer-dispersions is given in Chapter 3.

Chapter 4 deals with the synthesis and characterization of amino-quat-primer polymers. The structure and degree of quaternization of the products are confirmed. Moreover, the protonation behavior upon variation of polymer concentration, pH and salt concentration is investigated.

The preparation of silica-nanoparticle-dispersions containing amino-quat-primer polymers is described in Chapter 5. In addition, the optical investigation of the dispersions concerning their stability by means of turbidity measurements is discussed.

In Chapter 6, the results of the investigation of the stability of silica-polymer-dispersions regarding the defined key factors are given.

Chapter 7 summarizes the results of this thesis and gives an outlook of further possible uses of these findings.

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