3 Synthetic latex binders for paper manufacture
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3.1 Introduction

Latex (which in Latin means ‘fluid’) is a viscous, milky sap secreted by certain plants such as the Brazilian hevea, or rubber tree (*Hevea brasiliensis*). By flocculating latices of various vegetal origins, it was first applied industrially to obtain rubber, used in the beginning to waterproof fabrics and to make elastic cloths. The discovery of the vulcanization process in 1846 made it possible to mould a multitude of objects. Not until 1880, when it was applied to bicycle and automobile tires, did the production of natural rubber really take off. As the automotive and tire industries expanded, the supply of natural latices could no longer meet market demand. Moreover, during the Second World War the harvest of natural latex, chiefly in Indonesia and Malaysia, dropped from 1500 thousand tons to around 200 thousand tons. The industrialized countries therefore stepped up production of natural latex substitutes. These synthetics are dispersions made up of synthesized polymer particles (based on styrene and butadiene) maintained in aqueous phase suspension. On account of their physical resemblance and similar properties the noun ‘latex’ was used for all these synthetic dispersions.

The chemical industry became interested in synthesizing latices toward the end of the 1930s. Their researchers worked at first on vinyl-acetate-based compounds, whose production expanded at the end of the Second World War in the fields of adhesives and paints. This activity then diversified and developed in such different areas as additives for building materials, textiles, medicine, and, of course, functional or non-functional coating and surfacing of papers and paper boards.

Today the latices used in paper applications are mainly based on vinylic monomers [1, 2], such as butadiene, styrene, acrylics and acetates. These synthetic latices appear as a white, fluid liquid composed of polymer particles suspended in aqueous phase. These particles are between 0.1 and 0.5 microns in size, depending on the properties sought.

Certain characteristics and properties of papers and cardboards manufactured with these latices result from the chemical nature of the polymer and also from the initial dispersed state; i.e., they depend on the stability and the viscosity of the latex and on its aptitude to form a homogeneous
SYNTHETIC LATEX BINDERS FOR PAPER MANUFACTURE

polymer film and to wet pigments. We shall develop these four different points with respect to the constraints inherent in on-machine paper manufacturing after describing how these latices are synthesized.

3.2 From molecule to particle: latex synthesis

The process that can be used on an industrial scale is the technique of radical emulsion polymerization. Before describing this process the basic principles of radical polymerization and the types of monomers employed must be recalled.

3.2.1 Radical emulsion polymerization

The synthesis of latices is based on the principle of radical emulsion polymerization. This polymerization is carried out in a reactor generally containing monomers, water, one or more stabilizing emulsifiers, a water-soluble radical polymerization initiator and modifiers. The initiator is a chemical compound that decomposes when heated (between 50–100°C), introducing into the aqueous phase unstable free radicals that trigger polymerization by acting on the monomer molecules. The most commonly used radical initiator is persulfate (of potassium, sodium or ammonium) $S_2O_8^-$, which decomposes to give $\cdot SO_4^-$ radical ions.

When heated, the radical initiator is transformed into a radical $R\cdot$. This phase is called polymerization initiation:

$$R-R \rightarrow 2 R\cdot$$

The radical then encounters a monomer molecule, $M$, and transforms it into a radical.

$$R\cdot + M \rightarrow R-M\cdot$$

This new radical will react with another monomer molecule to give a new radical that is longer by one monomer unit. Generally speaking, a radical containing $n$ monomer units can react with a monomer to give a radical containing $n + 1$ monomer units. This phase is called polymerization propagation. For $n = 1$:

$$R-M\cdot + M \rightarrow R-M-M\cdot$$

For $n = N$:

$$R-(M)_n-M\cdot + M \rightarrow R-(M)_{n+1}-M\cdot$$

This chain reaction continues until a terminating reaction stops the chain by deactivating the radical. This terminating reaction is brought about by one radical acting on another. There are two types of terminating