Considerations for Cationization of Starch Using a Dry Process

There are several parts in a dry process technology for starch cationization that have an impact on the overall costs. These areas are:

- Chemicals
- Equipment
- Process conditions

A. Chemicals

Cationizing Reagent

When using QUAB® 188, you have to convert the reagent into its epoxide form by addition of stoichiometric amounts of alkali. However, there you are also forming a stoichiometric amount of sodium chloride (salt), which will stay in the starch. The higher the degree of substitution and subsequently the more QUAB® 188 needs to be added, the more sodium chloride will be found in the final cationic starch. For example, it can be estimated that a starch with a practical degree of substitution (DS) of 0.02 has a NaCl content of approx. 0.6% when using QUAB® 188. Increasing the DS by an increment of 0.01 increases the NaCl content by 0.3%. A starch with a DS of 0.06 has a NaCl content of 1.8%.

Catalytic Alkali

The state of the art alkali used in most of the processes is caustic soda used in aqueous solution. It gives a fast reaction and high reaction efficiencies. However, using caustic requires a very efficient mixer to homogeneously mix the caustic into the starch without pre-gelatinization (lump or granule formation).
In order to overcome the distribution problem, solid alkali can be used. Here, the cheapest source would be calcium hydroxide (lime). This alkali can be homogeneously mixed into the starch but has a very strong effect on the final starch viscosity. Lime decreases the paste viscosity strongly, especially if the reaction is carried out at higher temperatures or the starch is stored for a longer period prior to use. It also can lead to a discolorization of the starch to a yellow tint. Furthermore, the starch gets more hydrophobic and therefore it is more difficult to prepare a slurry of a dry cationized starch with lime used as the alkali.

Additives

Although it is called dry cationization, you still need water for the reaction. The optimum water content during the reaction is between 17 and 22% (depending on the type of starch and DS). In general, starches with such a high moisture content can not be conveyed and

stored without the problem of lump formation and agglomeration. It is therefore sometimes necessary to add free flowing agents to ensure a good workability during all process stages. The addition of a free flowing agent is especially important, if the reaction is carried out in a stationary reaction vessel (e.g. silo or big bag) and if the starch is not dried after the reaction is completed.

Neutralization chemicals

Today, almost all dry cationized starches are neutralized after the reaction is completed. In most cases this is done with a solid acid like adipic or fumaric acid as they can be mixed into the starch without any problems. Using a liquid acid is also possible but then additional water would be introduced into the starch and further conveying problems may result from that.

B. Equipment

The key factor for the dry process is to choose the right equipment namely the mixer. It is essential to use a high shear force mixer like the ploughshare or paddle type mixers (in batch operations) or high speed turning mixers like the recylcer types (for continuous operations). Additional devices like choppers or rotating knifes are also of importance.
The major task is to homogeneously distribute the liquid reagent and alkali (in case caustic is used) homogeneously in the starch without lump or bigger granule formation. It is therefore also important to use the right injection method, which in case of most batch operations is performed by pressure injection via nozzles. It is necessary to inject the liquid into the zone of highest agitation and turbulence, which is the area where the choppers are attached.

We have had contacts in the past to the German mixer company Loedige in Paderborn, who are supplying systems for the dry cationization. I would suggest that you contact them in order to get information about their design.

C. Process conditions

In general you have to decide whether you would like to have a batch, a semi-continuous or fully continuous system. This will define most of the equipment needed like mixers, weighing and dosing systems.
You also need to decide, whether you want to have the reaction at ambient temperature (in a silo or intermediate storage bins) or at elevated temperatures (either in a heat jacketed mixer or a heated silo/storage bin). Again, this can have an influence on the design of the equipment. Microwave heating has been reported to give excellent results in dry cationization reactions on a laboratory scale.