SIZE AND CHARGE ANALYSIS FOR THE PREDICTION OF GUSHING

CONTEXT

Gushing is the over-foaming of carbonated beverages when the bottle is opened, as shown in **Figure 1**. Gushing is an important quality feature of the beverage industry. This phenomenon can occur with all carbonated beverages, such as beer, spritzers, or water. Gushing is divided into primary and secondary gushing. Primary gushing is due to the raw materials of the beer. Secondary gushing can be traced back to nanoparticles of iron, calcium oxalate, or surfactants that are produced during production. Two protein groups are thought to be responsible for primary gushing. These are fungus-specific hydrophobics and non-specific lipid transfer proteins (ns-LTP) that are typical of the plant.

Figure 1: Gushing when opened

The goal of the research is now to find and characterise substances that promote or prevent gushing in order to be able to predict gushing. As gushing is caused by nanoparticles, as described above, colloid-chemical measurement methods such as dynamic light scattering and the flow potential in conjunction with charge titration are excellently suited for the analysis.[1-11]

FLOW POTENTIAL AND CHARGE TITRATION

Whether an interface to the liquid medium is a flat surface, a particle, or a molecular surface, the same laws apply to all of them. A charged surface attracts opposite-polar excess ions from the liquid environment, which shield the charge from the outside.

The loosely bound ions of the charge cloud (double layer) can be sheared off by an electric field or by mechanical work (flow). The potential that forms on the shear layer can be measured with the STABINO ZETA. There, the sample is set in motion in a kind of capillary, and the charge cloud is shifted in the direction of the flow, resulting in the flow potential (proportional to the zeta potential)

During the charge titration with polyelectrolyte solutions, the charge of the particles is neutralized, and thus, the total charge is determined. The zeta potential/flow potential is a measure of the stability of a dispersion, i.e., the higher or lower the potential or the titrated amount of charge, the more stable the dispersion. ***Figure 2*** shows the setup of the STABINO ZETA measurement for determining the interfacial charge.

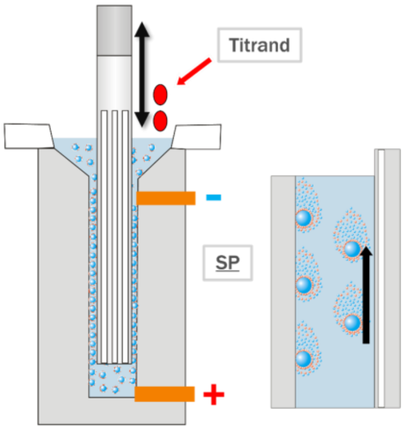

Figure 2: Setup of the STABINO ZETA. Oscillatory displacement of the ion cloud around the adhering to the porous walls of the PFTE sample container and flask due to the up and down movement of the positive displacement flask. The resulting oscillating charge cloud is tapped as a sinusoidal flow potential SP on the two electrodes.

180° Heterodyne Dynamic Light Scattering (DLS)

To determine the turbidity or colloidal stability of filtered beers, charge titrations were performed with the charge-calibrated cationic polyelectrolyte 0.001 N P-DADMAC (polydiallyl dimethylammonium chloride). In order to get a comparison to the forcing test, it was carried out in parallel. In the forcing test, a charge titration was carried out after each warm day, and the turbidity was measured at a 90° angle in EBC formazine units. [3, 4]

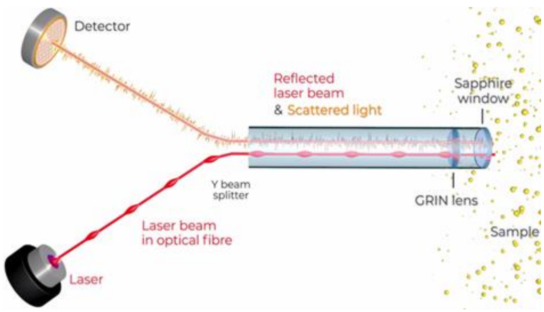

Figure 3: The 180° DLS method described in the text

The laser is focused on the sample through an optical fiber and a sapphire window. In the process, part of the incoming laser light is reflected off the sapphire glass. The laser light and the backscattered laser light interfere with the detector. Due to the excellent signal-to-noise ratio, no complex detection system.

The fluctuating part of the signal comes from the Brownian molecular motion of the particles and is converted into a power spectrum by the Fast Fourier method, which takes into account the laser frequency. Without further acceptance of the distribution model, the size distribution is calculated from the power spectrum.

RESULTS

When analysing surface-active surfactants, particles with a size between 1 nm and 2 nm were found. This particle size was also found in gushing-positive samples, so that it can be concluded that gushing can be induced by small nanoparticles. These small nanoparticles could not be detected in gushing-negative samples. ***Figure 4*** shows the difference between a gushing-positive and gushing-negative sample.[1-2]

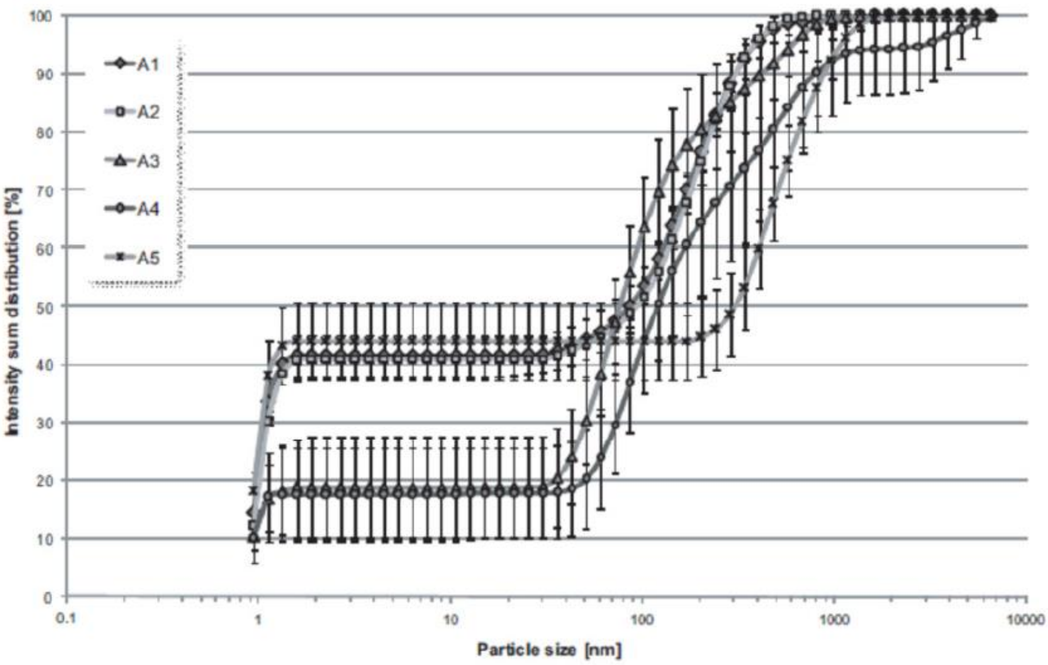

Figure 4: Difference between gushing-positive and gushing-negative samples.[1-2]

Samples A1, A2, and A5 are gushing-positive because they have a much larger proportion of nanoparticles between 1 and 10 nm in size, whereas samples A3 and A5 have only a very small proportion of the very small nanoparticles. In beverage samples that do not have gushing, these 1-2 nm nanoparticles could not be detected. This allows gushing-positive drinks to be distinguished from gushing-negative drinks. [1-2]

With the help of the flow potential and the associated charge titration, the results of the size measurement can be further verified. Since the samples examined here all had a negative flow potential, the samples were titrated with 0.001 N P-DADMAC (**poly-diallyl dimethylammonium chloride).** The titrations show that Gushing-positive samples have a higher consumption of P-DADMAC than the Gushing-negative samples, as shown in ***Figure 5***.[1-2]

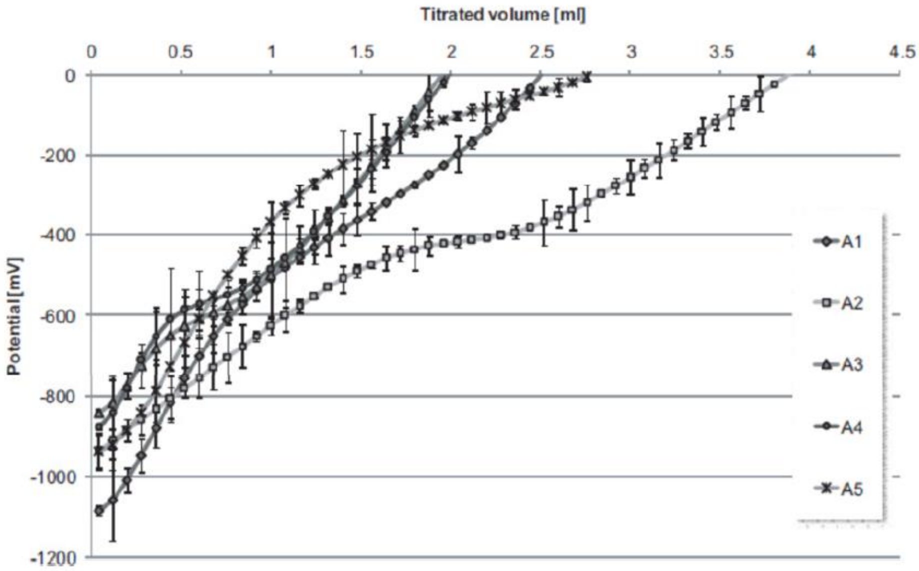

Figure 5: Titration curves of gushing-positive and gushing-negative samples.[1]

The fact that the gushing-positive samples have a larger consumption in contrast to the gushing-negative samples can be explained by the specific surface area. Many small nanoparticles have a larger surface area than larger nanoparticles. Therefore, the small particles can carry more charge in total than large particles.[1-2]

SUMMARY

By combining sizing and charge titration, gushing-inducing particles can be detected and quantified, making gushing predictable. In addition to gushing, there are other interesting applications in the beverage industry, especially for charge titration, such as a fast alternative to the forcing test and the rapid determination of nitrogen compounds during wort boiling.

LITERATURE

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