# SODIUM SILICATE PARTICLE SIZE MEASUREMENTS USING TIME - RESOLVED FLUORESCENCE ANISOTROPY

Daniel Doveiko[1], Simon Stebbing[2], Yu Chen[1], David J. Birch[1], Vladislav Vyshemirsky[3], Olaf Rolinski[1]

[1] Photophysics Group, Department of Physics, University of Strathclyde, Scottish Universities Physics Alliance, Glasgow G4 0NG, U.K.
[2] PQ Silicas UK Limited, Warrington, WA5 1AB, U.K.
[3] School of Mathematics and Statistics, University of Glasgow, Glasgow G12 8QQ, U.K.
daniel.doveiko.2018@uni.strath.ac.uka

Sodium silicates are versatile inorganic chemicals produced by combining silica sand and soda ash (sodium carbonate) under high temperature. When in aqueous solution, they are often used in coating and bonding applications. Additionally, they exhibit a range of attractive characteristics, such as being odorless and non-toxic, high strength and rigidity, resistance to high temperatures and low-cost [1].

The important characteristics of silicates are the correlation between the ratio of silica to soda concentrations and the size of the species. Traditionally, the particle sizes of nanoparticles are determined using methods such as Dynamic Light Scattering (DLS) [2], Small-Angle X-Ray Scattering (SAXS) [3], Small Angle Neutron Scattering (SANS) [4] and Transmission Electron Microscopy (TEM) [5]. All these methods are far from ideal and have significant drawbacks: DLS becomes difficult for particles below 10 nm, SAXS and SANS are expensive and complex, and TEM requires complex sample preparations which can lead to alterations of particle sizes [6-8].

Here, we present a new way of determining the particle sizes of sodium silicate liquors at high pH using time-resolved fluorescence anisotropy. Different from previous approach of using a single dye label, two fluorescent labels were used in this work [9,10]. Rotational times of the non-binding rhodamine B and electrostatically binding rhodamine 6G were used to determine the medium microviscosity and the silicate particle radius, respectively. This approach of using two dyes ensures that the microviscosity stays accurate in time, unlike in the case when a single dye was used. Applying this method to samples of various pH (prepared by diluting the stock solution of silicate to the concentrations of NaOH ranging from 0.2M to 2M) and different temperatures (10°C to 55°C), the recovered average particle size was found to have an upper limit of 7.0±1.2Å.

[1] Yang, X., W. Zhu, and Q. Yang, The viscosity properties of sodium silicate solutions. Journal of Solution Chemistry, 2008. 37(1): p. 73-83.
[2] Gratz, H., A. Penzkofer, and P. Weidner, Nanometer particle size, pore size, and specific surface determination of colloidal suspensions and porous glasses by Rayleigh light scattering. Journal of non-crystalline solids, 1995. 189(1-2): p. 50-54.
[3] Paradies, H.H., Particle size distribution and determination of characteristic properties of colloidal bismuth—silica compounds by small-angle x-ray scattering and inelastic light scattering. Colloids and Surfaces A: Physicochemical and Engineering Aspects, 1993. 74(1): p. 57-69.
[4] Winter, R., et al., A SANS study of the effect of catalyst on the growth process of silica gels. Journal of non-crystalline solids, 1989. 108(2): p. 137-142.
[5] Van Blaaderen, A. and A. Kentgens, Particle morphology and chemical microstructure of colloidal silica spheres made from alkoxysilanes. Journal of Non-Crystalline Solids, 1992. 149(3): p. 161-178.
[6] Uskoković, V., Dynamic light scattering based microelectrophoresis: main prospects and limitations. Journal of dispersion science and technology, 2012. 33(12): p. 1762-1786.
[7] Pauw, B.R., Everything SAXS: small-angle scattering pattern collection and correction. Journal of Physics: Condensed Matter, 2013. 25(38): p. 383201.
[8] Williams, D.B. and C.B. Carter, The transmission electron microscope, in Transmission electron microscopy. 1996, Springer. p. 3-17.
[9] Yip, P., et al. (2012). "Fluorescence anisotropy metrology of electrostatically and covalently labelled silica nanoparticles." Measurement Science and Technology **23**(8): 084003.
[10] Geddes, C. and D. Birch (2000). "Nanometre resolution of silica hydrogel formation using time-resolved fluorescence anisotropy." Journal of non-crystalline solids **270**(1-3): 191-204.