Novel Automated Torsional Crystal Viscometer for Liquids at High Pressures

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A torsional quartz crystal viscometer has been developed for absolute measurements of liquids. The instrument covers the temperature range from 200 to 420 K with pressures up to 100 MPa. The viscosity sensor consists of a piezoelectric quartz cylinder, which is excited to vibrate torsionally by an alternating electric field generated by the four electrodes surrounding it. One aim of this project is to reduce the uncertainty of the torsional crystal technique from currently 2 % to well below 1 %. This will be achieved by a well-founded analysis of the electrical field in the viscosity sensor and the mechanical vibration of the quartz cylinder. In a first step, the electric field in the sensor was analyzed in much greater detail than in previous studies. This analysis yielded previously unknown results, which lead to a novel sensor design. With the novel sensor, the bandwidth of the vibration in vacuum could be reduced by about 60 % and the dependence of the bandwidth of the vibration in the fluid on the drive voltage could be reduced significantly compared to previous torsional crystal sensors described in the literature. The viscosity sensor is mounted in a pressure vessel, which is thermostatted in a liquid bath thermostat. The pressure is measured by four piezoelectric transducers with stepped ranges of 3.45, 13.8, 41.1, and 103.4 MPa. Measurements along isotherms are automatically performed by setting the pressures by a syringe pump, which is controlled by the data acquisition computer. The resonance frequency and bandwidth of the vibration of the crystal are determined in the frequency domain from the conductance and susceptance curves of the sensor in the vicinity of the resonance measured by an impedance analyzer. Results of validation measurements with several fluids as well as a detailed uncertainty analysis will be presented.