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Title:

Full experimental proof of the relationship between the intrinsic viscosity of DNA and the acoustic ratio of SAW and TSM sensors

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Abstract

Acoustic wave sensors are extensively used in biotechnology and biophysics in order, for example, to detect molecules in a solution, study an antibody-antigen interaction or the hybridization of DNA. Today, data analysis includes (a) the use of the Sauerbrey equation, in order to calculate the mass of the molecules attached on the surface of the acoustic device by use of frequency data and (b) the use of complicated mathematical models of the assumed 'film' formed by the attached molecules. In the second case information such as the rigidity modulus and viscosity of the 'film' can be calculated and comments can be made on the softness (viscoelasticity) of the added layer.

Here, we present an entirely different approach. Based on a theory developed earlier[1,2] we correlate the acoustic ratio *R*, to the intrinsic viscosity [η] of the attached molecule. The acoustic ratio is the ratio of the amount of energy loss per attached unit mass – this is given as ($\Delta D/\Delta F$) in the TSM acoustic mode notification, or as ($\Delta A/\Delta Ph$) in the SH-SAW mode and is readily obtained in each experiment. The *intrinsic* viscosity on the other hand, is a hydrodynamic quantity directly related to the size and shape of a biomolecule and can be determined independently through viscometry. In this study we present collected experimental data from a variety of case studies proving for the first time the semi-empirically assumed relationship $R \sim [\eta]$ in a general form. Data are presented for various shapes and sizes of DNA and other systems of biological interest. The case is made for two acoustic modes (thickness shear and surface horizontal) and for various frequencies in the range of 5-155 MHz.

Our analysis presents a paradigm shift and challenge; we claim that (label-free) structure probing is a much more improved method offering higher flexibility in design and interpretation of experimental assays. Detecting and monitoring in real time processes that involve structural changes but not necessarily mass changes and/or 'film' formation is a novel concept that can be readily applied in anything from DNA, RNA hybridization and detection of mutations to molecular machines (e.g. DNA Holliday junction) and protein/DNA/RNA interactions in the broad areas of biophysics, structural DNA nanotechnology and diagnostics.

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References:

1. A. Tsortos, et al., "Quantitative determination of size and shape of surface-bound DNA using an acoustic wave sensor", *Biophys. J.* 2008, 94:2706
2. A. Tsortos, et al., "Shear acoustic wave biosensor for detecting DNA intrinsic viscosity and conformation: A study with QCM-D", *Biosens. Bioelectron.* 2008, 24:836