WHITE PAPER

NETZSCH

The Rheodialysis Approach

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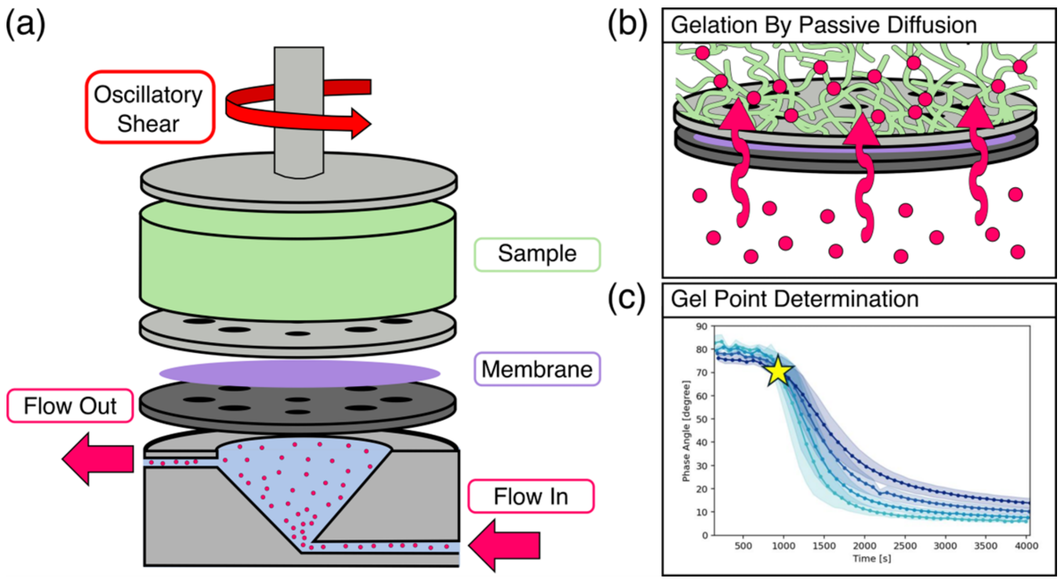
Context

A lmost all materials that can be probed through rheology are sensitive both to changes in mechanical forces and to changes in local chemical environment. All biological structures depend on this sensitivity, including blood clots, tissue, membranes and mucus. So too do industrial materials such as gels, pastes and suspensions. An often-unspoken dimension of this sensitivity is that chemical and mechanical stimuli rarely manifest themselves in isolation but more often occur in synergy. One example is the blood clots that facilitate wound healing, which resist enzymatic degradation when stressed but degrade readily upon removal of tension. Another example is the alginate biopolymeric hydrogels used in healthcare and food industries whose chemical environment depends on shear history and whose shear viscosity depends on their chemical environment. Finally, the cells in our body receive their mechanical integrity from polymeric-like structures that assemble and re-assemble continuously in response to simultaneous mechanical and chemical cues.

The Rheodialysis Approach

Rheodialysis is an experimental technique developed by the University of Liverpool and Durham University in close collaboration with NETZSCH Analyzing and Testing (Figure 1).



1 The Rheodialysis approach (a) A rheometer is equipped with a custom designed flow cell incorporating a porous membrane to allow buffer exchange of sample during rheological testing. (b) Among other uses (see below) this can be used to induce and probe gelation in-situ (b) Pilot data of a model biopolymer solution that forms a gel during ionic buffer exchange under oscillatory testing. Convergence of the oscillatory phase angles (yellow star) at different frequencies identifies the precise point of gelation.

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Briefly, the technique involves incorporating a customised flow cell with a porous membrane into the base of a NETZSCH Kinexus shear rheometer. Chemical environments such as buffers, solvents, acids or enzymes are introduced into the flow cell and enter the sample through passive diffusion, while standard rheological tests are carried out. The diffusion rate can be carefully controlled through adjustment of the flow rate in the cell and concentration of the solution used.

The rheodialysis approach allows users to control the chemical environment while simultaneously monitoring the rheological properties of the sample in real time. The injection system is automated using the rSpace software thereby synchronising chemical changes and rheological tests. The approach is easy to assemble and works with existing NETZSCH Kinexus rheometer and allows precise control over compositional changes and timescales, for example to model formulation, manufacture or end use of soft structured materials.

Example Applictions

Rheodialysis is a technique that has powerful applications for any soft material that is sensitive to chemical changes. The following represent several potential applications; however, this is not an exhaustive list, and we enthusiastically welcome discussions with users with ideas for possible new applications:

- Probing chemically induced gelation of polymers or polymer films in real time
- Simulating digestion of structured food while exposed to gastric fluid or enzymes
- Probing controlled release of reagents from pharmaceutical products, either at steady state or under applied shear
- Investigating the rheological response of creams or personal care products when exposed chemical environments such salinity or enzymes
- Testing changes in adhesive properties during chemical and mechanical wear

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