Viscoelastic properties of the fibrin network in blood clots

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Introduction
The fibrin network is an essential constituent of blood clots (fig. 1).
• Important for mechanical properties
• Structure is influenced by flow

Goal: To develop a numerical model able to describe the mechanical properties of the developing fibrin network under flow.

Methods
Model:
• Transition from a fluid to a solid (fig. 2)
• Governed by fibrinogen kinetics (fig. 4, left)

Experiments:
• Rheometer experiments
• Small, oscillatory shear deformation
• Results compared with model output (fig. 3)

Results

Conclusion
A constitutive model is developed that describes the viscoelastic properties of the developing fibrin network based on its structural properties.

Future work:
• Further experimental validation
• Inclusion of porous properties

Figure 1. The formation of a fibrin fiber. The first step is the formation of regularly structured protofibrils, composed of fibrin molecules (1). Protofibrils polymerize to form fibrin fibers (2).

Figure 2. The solution of fibrinogen molecules is modeled as a liquid. When the network develops, a transition takes place towards a solid.

Figure 3. The transition from a fluid to a solid is indicated by a decreasing phase angle $\delta$ in time. The solid line shows the prediction, the dashed line is a measured result.

Figure 4. The conversion of fibrinogen is governed by the Michaelis-Menten equation that relates the fibrinogen concentration $c_{fg}$ to the thrombin concentration $c_{tr}$ (left). The right panel shows increasing elastic and viscous modulus during network formation.