The radial pattern of brittle viscoelastic fluids between rotating parallel plates

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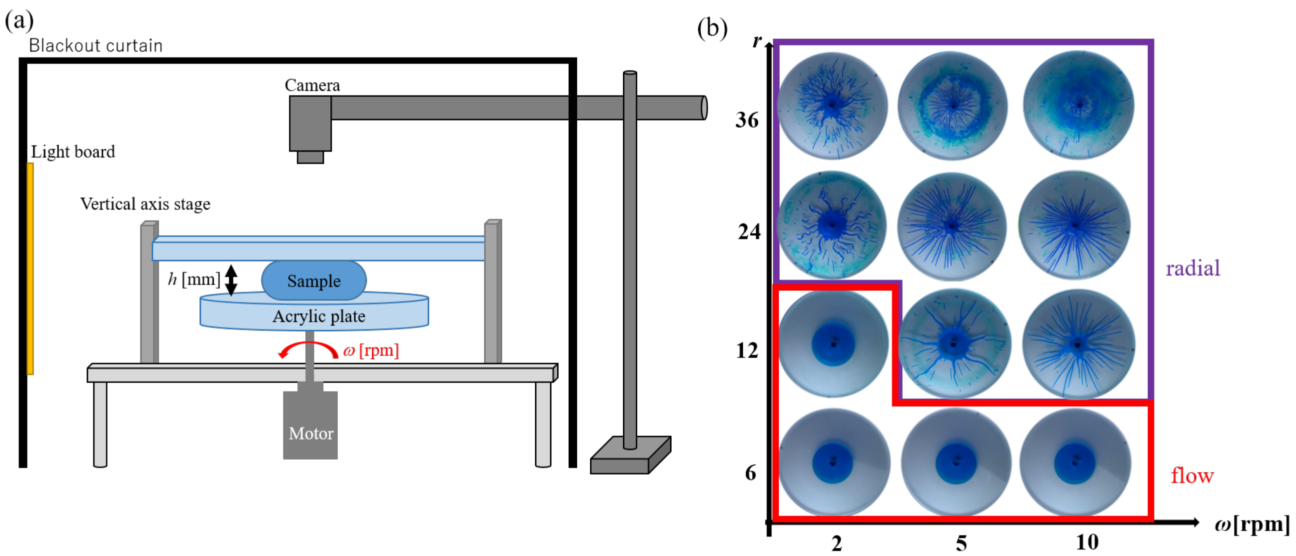
Slow earthquake occurs at marginal region between seismogenic and steady sliding zones[1]. At the seismogenic zone, a subducting plate can be recognized as brittle elastic solid, whereas the plate can be recognized as ductile viscous liquids at the steady sliding zones. For this reason, we assume that the marginal material behavior, viscoelasticity, can be relevant to general slow earthquakes. Here we report the analogue experimental system with viscoelastic fluids under continuous shear with rotating plates.
As a viscoelastic fluids, we used a gel, which is mixture of micro emulsion with telechelic polymer, so called bridged emulsion. One reason for using this sample for the present experiment is that the gel is known to behave as an ideal Maxwell fluids with single relaxation time under linear oscillatory shear. Another reason for the choice of this gel is, in nonlinear rheological regime, the gel behaves as brittle solid with low fracturing energy at the shear rate higher than the inverse of the relaxation time. The gel is made from the mixture of cetylpyridinium chloride(CPCl), octanol, decane,0.2M NaCl aq, and poly (ethylene glycol) distearate as telechelic polymer, which has hydrophilic main chain with hydrophobic ends[2]. As a parameter, we changed the concentration of bridging telechelic polymer, which determined the shear modulus and relaxation time.
In order to observe long term behavior of sample under shear, we used rotating plates as an experimental geometry as shown in Fig. (a). A plate is rotated with fixed angular velocity on the other plate. The gap between the plates was kept as 1 mm. The angular velocity was used as the other parameter. The typical behavior of the sample is shown in Fig. (b). We found that the sample showed radial pattern when the angular velocity was large enough, whereas the radial pattern is absent for the small angular velocity. This transition of pattern was controlled by the characteristic shear rate which is determined by the relaxation time of the samples. Indeed, we observed the coexistence of flow and the radial patterns when the angular velocity was marginal. Such behavior can be understood due to the liquid and elastic nature of the sample depending on the shear rate.

[1] K. Obara, A. Kato, Science 353, 253-257 (2016).
[2] M. Filali and J. Appell, J. Phys. Chem. B 103, 7293-7301 (1999).


(a)
Blackout curtain
Camera
Light board
Vertical axis stage
h [mm]
Sample
Acrylic plate
ω [rpm]
Motor
(b)
r
36
24
12
6
2
5
10
ω[rpm]
radial
flow

