平成 9 年度博士論文英文要旨

- 平成7年度入学　大学院博士後期課程　物質工学専攻（材料物理工学講座）

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論文題目：　二成分液体系における ER 効果の発現メカニズムの解明

英訳題目：　Mechanism of ER Effect for Immiscible Liquid Blend

Abstract

The ER effect is defined as a change of rheological properties of fluidsby application of the electric field. The fluids which show the ER effectare called ER fluids. The author has developed new type of ER fluids whichare the blends of urethane-modified polypropylene glycol (UPPG) and dimethylsiloxane(DMS). These are immiscible blends and have domain structures. There hasbeen, however, no observation of the domain structure under simultaneousapplication of electric field and shear flow. In this thesis, a newly designedapparatus for the domain observation under the electric and shear fieldshas developed, and the relation between the domain structure and the EReffect has been studied. The results show that the domain structure changesby applying the electric field as follows:
(1)When the weight fraction of DMS fD is less than 23wt%, UPPG forms thematrix and DMS forms the droplets under no electric field. The structuredoes not change by applying the electric field, and there is no ER effect.
(2)When 23wt%<fD<26wt%, the phase structure under no field is theopposite to that observed in case (1); UPPG forms the droplets and DMS formsthe matrix under no electric field. On applying the electric field, thephase inversion occurs; UPPG forms the matrix and DMS forms the droplets.In this case, the ER effect appears.
(3) In the case of fD >26wt%, UPPG forms the droplets and DMS forms thematrix under no electric field, as in the case (2). On applying the electricfield, the coalescence among the droplets and elongation of droplets
in the field direction occur simultaneously, and eventually UPPG bridgesbetween the electrodes. Under both the electric field and shear flow, UPPGmoves up and down between the electrodes, and bridges between the electrodes.In this case, there is a large ER effect. Thus, it is clarified that thecause of the ER effect is the change of the domain structure under the electricfield.
In the case of fD >26wt%, UPPG forms droplets under no field, so theblend viscosity is dominated by the low viscosity DMS phase. When the electricfield is applied, UPPG bridges between the electrodes, so the blend viscosityis dominated by the high viscosity UPPG phase. This is the basic mechanismof the ER effect.

In the traditional ER fluids, the ER effect has been observed as the increaseof its viscosity by the field (positive ER effect), and there are only veryfew reports of the negative ER effect (decrease of the viscosity by thefield). However, the above mechanism of the ER effect in the immiscibleblends suggests that the negative ER effect may be observed if DMS withhigher viscosity than UPPG is used. We have studied the blends of UPPG withhigher viscosity DMS, and found that the viscosity of the blend indeed decreasesby the electric field due to the domain structure change.

The result of this thesis shows that there are two necessary conditionsfor the existence of the ER effect in immiscible blends. The first conditionsof the existence of the ER effect is that the domain structure changes byapplying the electric field; the droplet phase coalesce and connect theelectrodes under the field. The cause of this change of the domain structureis the difference of the dielectric constant and conductivity between dropletsand matrix, and we have found that the droplet phases with higher dielectricconstant and conductivity than the matrix phase are most suitable. The secondcondition of the ER effect is that the viscosity of droplets and matrixare different; if the droplets have higher viscosity than matrix, positiveER effect appears, and vice versa.