RHEOLOGY AND COLLOID PROPERTIES OF O/W/O MULTIPLE EMULSIONS CONTAINING ACRYLATE POLYMER

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Oil-in-water-in-oil (o/w/o) multiple emulsions are systems where small oil droplets are entrapped within larger water droplets that in turn are dispersed in a continuous oil phase. Because of the presence of aqueous phase, which acts as a membrane between the internal and external oil phases, o/w/o emulsions can be used to prolong release of oleophilic active ingredients (e.g., drugs). These emulsions provide a basis for innovation in many applications for pharmaceutical and cosmetic industries. An understanding of the rheological behavior of double emulsions is important for formulating, mixing, processing, and storing such systems. Rheological studies can give useful information on the stability and microstructure of multiple emulsions. So far a little attention has been drawn to the rheology of these emulsions, especially containing polymer components. In our opinion o/w/o emulsions including pressure-sensitive polymeric adhesive may be effective for preparation of nano-dispersed heterophase films as matrices for transdermal delivery of hydrophobic drugs.

In this study $o_1/w/o_2$ double emulsions were prepared using two-step procedure and magnetic stirring. The primary o_1/w emulsion was stabilized by surfactant Tween 80 that had a high Hydrophile-Lipophile Balance (HLB = 15) and by hydrophilic polymer hydroxypropylcellulose (HPC, M_w 80000). Glycerol monooleate (GMO) with low HLB ~ 4 was added in internal oil phase (o_1 – hexane) and lipophilic acrylate polymer (Duro-Tak 87900a, DT) - to the outer continuous oil phase (o_2 – ethyl acetate). It is important, that GMO is an effective enhancer of skin permeability and acrylic polymer is a pressure-sensitive adhesive. The weight fractions of the primary o_1/w emulsion and of the aqueous phase in $o_1/w/o_2$ double emulsion were ~ 0.45 and ~ 0.25 respectively. Emulsions contained 2-5% GMO, 1-3% Tween 80, 2-10% HPC and 10-45% acrylate polymer. It was shown that increasing concentration of GMO results in increasing stability and transformation of emulsion type from o/w/o double to w/o inverse emulsion. Emulsions were stable for ~ 24 hrs. Morphology of emulsions was investigated with optical microscope "Axioskop 40 A Pol" (Carl Zeiss) and these results confirm that emulsions are double. The size of the inner droplets (o_1) was estimated to be less than one micron. The broad distribution in size (~ 10 - 200 μ) of large water drops containing small oil (o_1) drops is observed.

Rheological measurements were carried out on RheoStress-1 rheometer ("ThermoHaake", Germany) equipped with cone-and-plate operating unit (α = 2°, d = 60 mm). The rheological behavior of fresh emulsions was studied in steady shear, creep and recovery, and a sinusoidal oscillatory regimes at 20°C. Non-Newtonian flow of multiple emulsions was detected. The steady-state shear viscosity decreases with shear rate and increases noticeably as the DT content increases. When emulsions were tested in a mode of creep their viscoelastic behavior corresponds to complex rheological model consisting of Newtonian viscous element sequentially linked with Kelvin model. Dynamical mechanical analysis of emulsions in the linear viscoelastic region has shown that the loss modulus G`` is higher than the storage modulus G` over the entire frequency range, that means that samples are more viscous than elastic. Ultra-dispersed heterophase adhesive films were obtained on the basis of double multicomponent emulsions using the coating process.

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