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VARIOUS IMPACT RESISTANCE CAPABILITIES OF TAPIOCA STARCH BASED SHEAR THICKENING FLUID (STF)

(PELBAGAI KETAHANAN TERHADAP IMPAK BAGI CECAIR MENEBAL RICIH BERASASKAN TEPUNG UBI)

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VARIOUS IMPACT RESISTANCE CAPABILITIES OF TAPIOCA STARCH BASED SHEAR THICKENING FLUID (STF)

ABSTRACT

STF is a non-Newtonian flow behaviour often observed in concentrated colloidal dispersions characterized by significant, sometimes discontinuous increase in viscosity with increasing shear stress. Examples are concentrated particle colloidal suspensions such as photographic dies, paints, coatings and lubricants. When such fluid is subjected to a high-enough shear stress, it can lead to a rapid, sometimes discontinuous, increase in viscosity. The change in viscosity is due to the change of molecular arrangement structure in the colloidal suspension which usually will change from disordered liquid to ordered liquid crystals. Triangle Ternary Phase Diagram can be classified as a diagram that represents the equilibrium between the various liquid crystal (LC) phases that are formed between three components. The optical and mechanical properties of ternary mixtures of Water/Tapioca Starch/Triton X-100 were studied by Polarizing Optical Microscope (POM), Simultaneous to Wide Angle X-Ray Scattering (SWAXS) and Rheometer. POM and SWAXS were used for phase identification and structure characterization. Rheometer was used to investigate the rheological properties of LC. Three different temperatures were used in this study: 15^{o}C, 25^{o}C and 45^{o}C. Several texture and optical pattern were examined under the POM. The ternary phase diagram systems obtained in this work tend to form different LC phases with the increase of concentration and temperature of the mixtures. Two types of LC were formed namely Lyotropic (LLC) and Thermotropic (TLC). Lamellar and micelle phase were formed in the LLC while nematic phase was formed in TLC. Optical investigation was done by examining the change of phase in the LC according to the change of temperature and amphiphile concentration. The phase transitions of TLC was found to depend on the temperature, while for the LLC, it depends on both the temperature and concentration. SWAXS was studied with the finding of lattice spacing, *d* value of LC: 96.61 Angstrom for the sample 40:30:30 of Water/Tapioca Starch/Triton X-100 at 25^{o}C as an example. The values of *d* are in agreement with the Bragg's Law where the values of *d* increases with increasing temperature. Futhermore, the viscosity-shear rate-shear stress plot was discussed based to the rheological properties.

PELBAGAI KETAHANAN TERHADAP IMPAK BAGI CECAIR MENEBAL RICIH BERASASKAN TEPUNG UBI

ABSTRAK

Penebalan ricih adalah satu sifat perngaliran bukan Newtionian yang seringkali dapat dilihat di dalam larutan koloidal yang pekat yang mana dapat dicirikan dengan peningkatan kelikatan dengan apabila dikenakan tekanan ricihan secara menaik. Sebagai contoh sistem suspensi koloid adalah pewarna fotografi, cat, penyalut dan pelincir. Apabila cecair tersebut dikenakan tekanan ricihan yang cukup tinggi, ia boleh menyebabkan kenaikan kelikatan secara mendadak. Perubahan kelikatan adalah disebabkan berlakunya perubahan struktur sususan molekul-molekul di dalam suspensi yang mana selalunya akan berubah daripada cecair yang tidak tersusun kepada hablur cecair yang lebih tersusun secara berperingkat. Rajah segitiga fasa boleh diklasifikasikan sebagai rajah yang memperlihatkan perbezaan di antara fasa Cecair Kristal (LC) yang terbentuk hasil daripada campuran tiga bahan berbeza. Pencirian sifat optik dan mekanikal bagi campuran bahan Air/Kanji Ubi Kayu/*Triton X-100* dikaji dengan menggunakan *Polarizing Optical Microscope (POM), Simultaneous to Wide Angle X-Ray Scattering, (SWAXS)* dan *Rheometer*. *POM* dan *SWAXS* bertujuan mengenalpasti fasa dan pencirian struktur fasa. *Rheometer* bertujuan mengkaji sifat reologi oleh LC. Tiga suhu yang berbeza digunakan dalam kajian ini: 15^{o}C, 25^{o}C dan 45^{o}C. Pelbagai bentuk dan corak diuji dengan menggunakan *POM*. Rajah segitiga fasa akan menunjukkan perbezaan antara fasa LC bergantung kepada peningkatan kepekatan dan suhu campuran. Dua jenis LC yang terbentuk dinamakan *Lyotropik* (LLC) dan *Termotropik* (TLC). Fasa *lamellar* dan *micelle* dihasilkan pada LLC manakala bagi *nematic* adalah TLC. Pencirian optik dilakukan dengan berpandukan kepada perubahan fasa LC bergantung kepada perubahan suhu dan kepekatan *amphiphile*. Perubahan fasa bagi TLC bergantung kepada suhu manakala bagi LLC bergantung kepada suhu dan kepekatan. Kajian SWAXS melalui pencarian nilai bagi jarak lattice, *d* oleh fasa yang terhasil: Menunjukkan nilai jarak lattice dan pencirian reologi LC ialah 96.61 Angstrom oleh sampel 40:30:30 Air/Kanji Ubi Kayu/*Triton X-100* pada suhu 25^{o}C. Nilai *d* dapat dikaitkan dikaitkan dengan Hukum Bragg di mana *d* bertambah dengan suhu. Selain itu, graf kelikatan-kadar ricih-kadar tekanan turut dibincangkan di dalam pencirian reologi.

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ABBREVIATION

Abbreviation	
LC	Liquid Crystal
LLC	Lyotropic Liquid Crystal
TLC	Thermotropic Liquid Crystal
MLC	Metallotropic Liquid Crystal
POM	Polarizing Optical Microscope
SWAXS	Simultaneous to Wide Angle X-Ray Scattering
STF	Shear Thickening Fluid
SEM	Scanning Electron Microscope
EDS	Energy Dispersive X-Ray Spectroscopy
UMP	Universiti Malaysia Pahang
UKM	Universiti Kebangsaan Malaysia

APPENDIX LIST

CHAPTER 1

INTRODUCTION

1.1 Project Background

The liquid crystalline state has been discovered about 100 years ago when Reinitzer and Lehmann (1888) investigated some esters of cholesterol. The field of liquid crystal (LC) developed increasingly in the following decades and about 1970 many researcher in this field believed that the basic knowledge about the LC state would be clear and future research would only serve to detect some details and to fill some gaps. Due to many new discoveries the field of LC has been more enlarged in the last 20 years than in its preceding 80 years of research.

LC can be divided into thermotropic, lyotropic and metallotropic phases. Thermotropic Liquid Crystal (TLC) exhibits a phase transition into the LC phases such as nematic or smectic LC phase when temperature is changed while Lyotropic Liquid Crystal (LLC) exhibits phase transition as a function of both temperature and