Physical Characteristics of Mustard Oil Solvent Miscella

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During commercial solvent extraction of oil from an oilseed, it is necessary to determine oil content in the miscella, drawn intermittently from the extractor, to obtain an overall extraction rate. We measured optical density, specific gravity, refractive index and viscosity of miscella of different known oil concentrations. These four characteristics were measured by calculating deviations from the actual values. The deviations were maximum for optical density, intermediate for specific gravity and viscosity, and small for refractive index, suggesting the latter to be an appropriate rapid method of determining miscella oil content.

KEY WORDS: Miscella, mustard oil, physical characteristics.

There is a growing need in the Indian oil-milling industry for a rapid method for determining the oil content of the miscella as it comes out of the solvent extractor, as well as during distillation and desolventizing operations.

Several studies have reported density-composition-temperature data for determining the composition of oil-solvent mixtures and have presented equations to calculate the specific gravity of a mixture at a particular temperature. The mixtures exhibited near ideal behavior at lower oil content, but for higher oil concentrations, the deviations from the values calculated from Raoult's law for ideal solutions were appreciable (1-8). Commercial hexane was the solvent widely used as the ideal medium for determining miscella concentration. Some other solvents were less suitable because associative interactions between solvent and oil molecules resulted in greater deviations in the measured physical properties of the miscellas (9).

We determined optical density, refractive index, specific gravity and viscosity of mustard oil-normal hexane miscellas as a function of concentration. A comparative evaluation of these four characteristics was made to establish a standard, rapid and practical method for determining miscella concentrations in Indian oilseed mills.

MATERIALS AND METHODS

Miscella samples of normal hexane and mustard oil were prepared with oil contents ranging from 1 to 10 % (vol/vol) and were kept at constant temperature in a water bath maintained at 25°C. Optical density, specific gravity, refractive index and viscosity of each miscella sample were determined at 25°C by spectrophotometer, pycnometer, Abbey refractometer and falling-ball viscometer, respectively (10,11). Calibration curves were drawn for each property of the miscella samples. The following expression was used to calculate miscella viscosity (11):

$$\mu_f = 0.009586(2.408 - \varrho_f)t \qquad [1]$$

where μ_f is the dynamic viscosity of the liquid, expressed in cp; ϱ_f is the specific gravity of the liquid; and t is the fall time in seconds of the steel ball in the liquid.

For comparative evaluation of the methods to predict the correct value of oil concentration, a miscella sample with an oil content of 3.2% (vol/vol) was prepared and kept in a constant temperature water bath maintained at 25°C. Optical density, specific gravity, refractive index and viscosity were determined by methods outlined in the previous paragraph. The percentage deviations of the actual oil content from that obtained from individual calibration curves for each instrument were calculated: Deviations at two other oil concentrations of 5.5% (vol/vol) and 8.5% (vol/vol) were similarly determined. Experiments at each oil content were replicated three times, and the average deviation for each instrument was calculated.

RESULTS AND DISCUSSION

Optical density. The optical density of miscella of different oil contents measured at 25°C and a wavelength of 475 nm are shown in Figure 1A. The rate of increase in optical

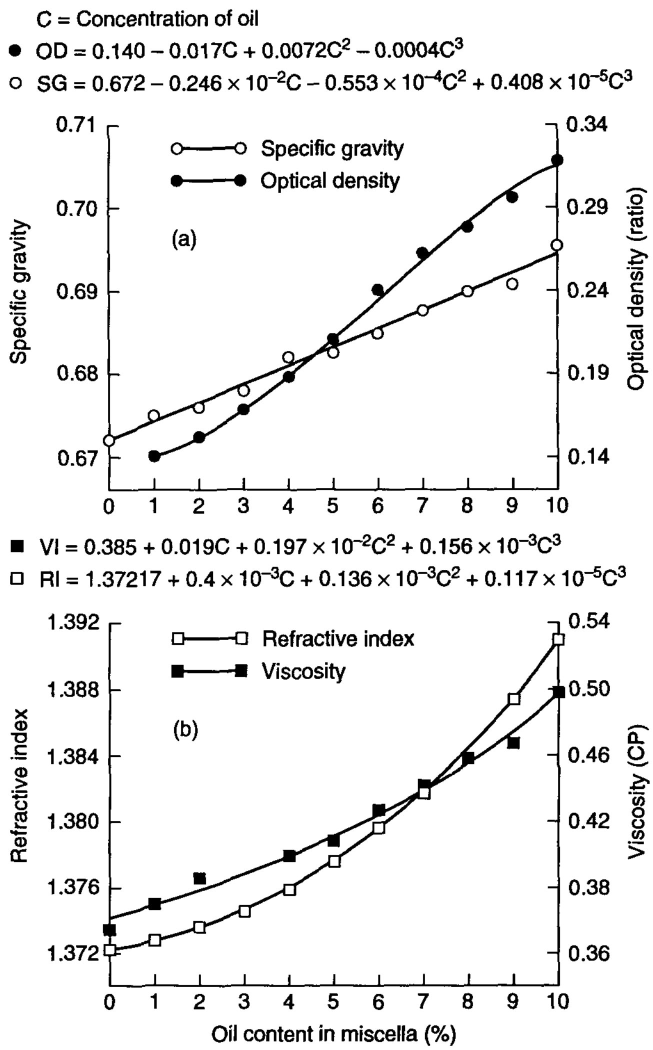

FIG. 1. Physical characteristics of mustard oil miscella. A: Optical density (OD) and specific gravity (SG) as a function of oil concentration. B: Viscosity (VI) and refractive index (RI) as a function of oil concentration.

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density with oil concentration accelerates and then falls off beyond 7% oil.

Specific gravity. The specific gravity of miscella samples (25°C) are also shown in Figure 1A. The observed linear relationship between specific gravity and oil concentration suggests that the latter may be determined by careful measurement of the specific gravity of the miscellas.

Refractive index. The refractive indices of miscella samples (25°C) increased exponentially with increase in oil concentration (Fig. 1B).

Viscosity. The viscosities of miscella samples (25°C) also increased exponentially (Fig. 1B).

Comparative evaluation. Analysis of the data and results, as shown in Figure 1, indicate that the refractive index measurement of the miscella at 25°C yielded the least percent deviation of 0.036%, compared to 0.50, 0.70 and 0.77%, for viscosity, specific gravity and optical density measurements, respectively. Moreover, refractive index measurement requires only a few drops of miscella and less time as compared to measurement of the other physical properties. So, under Indian oil-milling conditions, in-process measurement of miscella refractive index seems to be the most convenient and accurate method for rapidly determining oil content.

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