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Evaporation Study of Peppermint Flavor in Surfactant-Alcohol Systems

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Abstract: Peppermint, which occurs abundantly in nature, is used widely in various industrial sectors such as food, cosmetics and personal cares. For consumers, one of the perceptions of a good and desirable product is long lasting flavor. As peppermint is a volatile flavor compound, evaporation behavior of peppermint in surfactant-alcohol systems was investigated. It was found that surfactant-alcohol systems have the ability to reduce evaporation rate of the sample in decreasing order as follow: surfactant-heptanol > surfactant-decanol > surfactant-dodecanol. It was also observed that evaporation of Tween20-alcohol mixtures decreased with increasing surfactant (Tween20) concentrations in the mixtures. In the presence of 1% peppermint, evaporation of the mixtures was markedly reduced as compared with that of the individual compound or Tween20-alcohol mixtures without peppermint.

Key words: Peppermint, Tween20, alcohol, evaporation

Abstrak: Peppermint yang banyak terdapat dalam alam semulajadi diguna secara meluas dalam berbagai industri seperti industri makanan, kosmetik dan dandanan diri. Bahan perisa yang kekal lama di dalam sesuatu produk dianggap baik dan sangat dikehendaki oleh pengguna. Peppermint adalah sebatian perisa yang mudah meruap. Pelakuan penyejatan peppermint dalam sistem surfaktan-alkohol telah dikaji. Hasil kajian mendapati sistem campuran surfaktan-alkohol mampu mengurangkan kadar penyejatan mengikut urutan berikut: surfaktan-heptanol > surfaktan-dekanol > surfaktan-dodekanol. Hasil kajian juga menunjukan penyejatan sistem campuran Tween 20-alkohol berkurang dengan pertambahan kepekatan Tween 20 di dalam campuran. Pengurangan penyejatan yang nyata dapat dilihat dalam sistem campuran mengandungi 1% peppermint berbanding dengan sebatian tulin atau campuran tanpa peppermint.

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Introduction

Perfume or flavor plays an important role in human life, as it has been associated with notion of happiness, beauty and satisfaction. It is present in almost all cosmetics, personal care and food products [1,2]. Normally, this volatile substance is compounded with other components such as emulsifiers or solubilizers, to reduce its evaporation rate so as to prolong the flavor of the products. Isotropic solution, especially in the micellar or microemulsion system was used in order to obtain a desirable controlled release of the perfume [3,4].

Similar to perfumes, nonionic surfactants are also used in many industrial applications (medicines, cosmetics and detergents), as emulsifiers and solubilizers because of their low stimulation on the skin [5]. These surfactants can be used as a substitute for alcohol for the formation of micelles or microemulsions. However, it is essential to investigate the evaporation profile of perfume in surfactant-alcohol system to understand how the fragrance behaves.

Materials and Methods

Materials

Nonionic surfactant, polyoxyethylene (20) sorbitan menolaurate or Tween20 with purity of >99%, and peppermint (purity >99.5%) were obtained from Fluka. Alcohols of n-heptanol (C7-OH), n-decanol (C10-OH) and n-dodecanol (C12-OH) with purities of >99%, >97% and >99% respectively were obtained from BDH Chemical. Sodium chloride (NaCl, 99.5% purity) was purchased from Fluka. All the chemicals were used without further purification.

Methods

Three samples of mixed Tween20:C7-OH with different weight ratios (25:75, 50:50 and 75:25) were selected for the evaporation study. The mixtures were prepared with and without 1% (by wt) of peppermint. The evaporation study was conducted at a constant 87% RH (relative humidity) by placing the sample in a fully covered desiccator. The samples were weighted to determine the weight loss every 5 minutes for the first hour and subsequently every 10 and 15 minutes for the next two hours of measurement. The evaporation rate of the samples was determined, based on the weight loss or gain during the period, by deducting the final weight from the initial weight of the sample.

Similar experiments were then repeated with different alcohol , C10-OH and C12-OH.

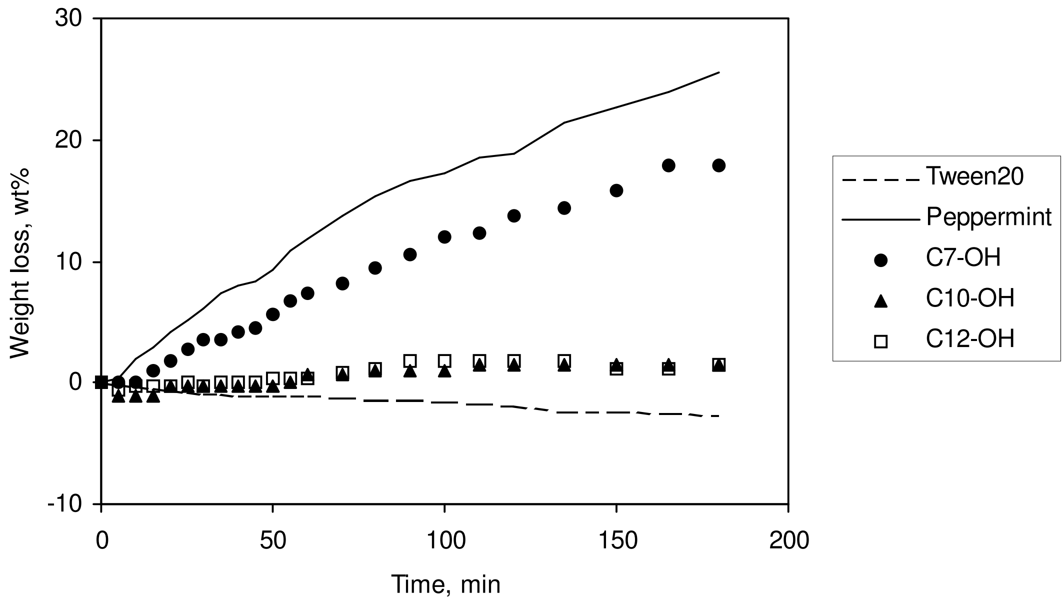

Fig.1. Percentage of weight loss of individual compound due to evaporation at 87% RH.

Evaporation rates of pure alcohol, Tween20 and peppermint were also conducted and served as the control.

Results

Figure 1 shows the percentage of weight loss, which was due to evaporation of individual compounds at 87% RH. In comparison, peppermint is the most volatile compound followed by C7-OH, C10-OH and C12-OH, and lastly Tween20. Both C10-OH and C12-OH alcohols have similar evaporation trends, whereas Tween20 was observed to absorb moisture from the surrounding environment to give an increase in weight (negative weight loss) at this relative humidity.

Different mixtures of Tween20 and C7-OH were employed and their evaporation rates (based on weight loss of the samples) were observed (Fig.2). The percentage of weight loss increases with decreasing concentrations of Tween20 in the Tween20:C7-OH mixtures. Both 25:75 and 50:50 of Tween20:C7-OH mixtures have higher evaporation rate than the individual compounds (Tween20 and C7-OH) after 30 minutes, whereas evaporation at

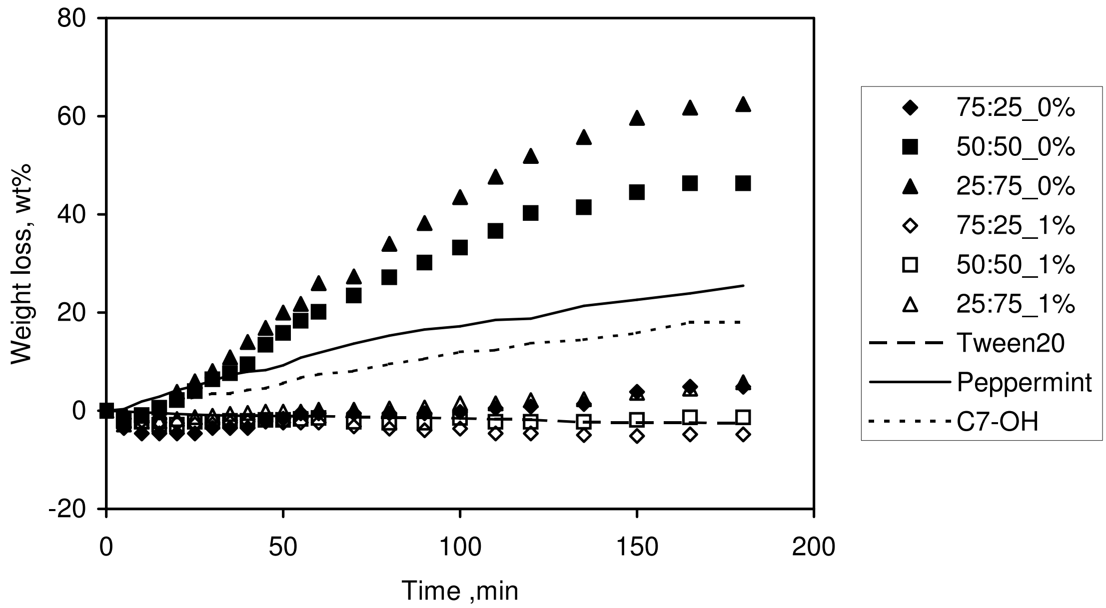

Fig. 2. Percentage of weight loss of different Tween20:C7-OH weight ratios at 0% and 1% peppermint (Tween20:C7-OH_1%) at 87% RH.

75:25 falls between the individual compounds after 60 minutes.

When 1% of peppermint was added into Tween20:C7-OH systems, the evaporation of the mixtures decreases dramatically as compared with those of pure peppermint and Tween20:C7-OH mixtures without peppermint. All samples containing peppermint are hygroscopic (absorbing moisture) below 50 minutes (see Fig.2). Above 50 minutes, sample of 25:75 weight ratio of Tween20:C7-OH begins to evaporate. At 50:50 weight ratio the evaporation trend of Tween20:C7-OH was similar to that of pure Tween20. However, at 75:25 weight ratio, the sample continues to exhibit hygroscopic properties even up to 180 minutes. At this ratio the weight loss was the lowest among the Tween20:C7-OH mixtures.

As the alcohol chain length increased from C7 to C10, the evaporation rate decreases as shown in Fig.3. All the Tween20:C10-OH mixtures exhibit an increase in weight as a result of adsorbing moisture from the surrounding environment (the weight loss varied from low to negative values). The increase in concentration of Tween20 in the Tween20:C10-OH mixtures was observed to increase the weight of the mixtures. This is because all the mixtures exhibit a strong hygroscopic property instead of evaporation. Again, the evaporation of mixtures containing 1 wt% of peppermint is markedly reduced to between Tween20 and C10-OH evaporation lines. Only in the 75:25 weight ratio of Tween20:C10-OH mixtures does the evaporation profile fall below Tween20 line.

Mixtures of different Tween20:C12-OH weight ratios also exhibit similar trends as Tween20:C10-OH systems, where 75:25 and 50:50 weight ratios of Tween20:C12-OH have high moisture absorption capability than the individual compound. The evaporation of Tween20:C12-OH system with 1 wt% peppermint does not show much variation as compared to the Tween20:C12-OH system without peppermint.

Discussion

As noted in Fig.1, the decrease in evaporation of alcohol compound with an increase of hydrocarbon chain length was mainly due to the decrease of vapour pressure of the compound. Pure peppermint, which consists of an aromatic ring, exhibits a higher vapour pressure than the alcohol compounds. Tween20, a nonionic surfactant, increases in weight with time. This is probably due to the surrounding environment (87% RH), which induces the Tween20 to exhibit hygroscopic properties (absorbing moisture).

However, different evaporation trends were observed in mixed surfactant-alcohol systems as compared with those of pure compounds, and also in different ratios of Tween20:alcohol mixtures (see Figs.2 and 3). This was due to the different degree of interaction between surfactant (Tween20) and alcohol molecules. In Fig.2, a synergy effect was noted at 25:75 and 50:50 weight ratios of Tween20:C7-OH system. An increase in the evaporation rate (based on weight loss of the sample) at these weight ratios, indicates weak interactions between Tween20 and C7-OH molecules. The presence of Tween20 in the system also deterred the interactions among C7-OH molecules. These factors contributed to the sharp increase in evaporation of mixed Tween20:C7-OH systems, as can be seen in the 25:75 and 50:50 weight ratios. At high concentrations of Tween20, 75:25 weight ratio of Tween20:C7-OH, the evaporation line was almost comparable to the evaporation of pure Tween20. However, the evaporations of mixed

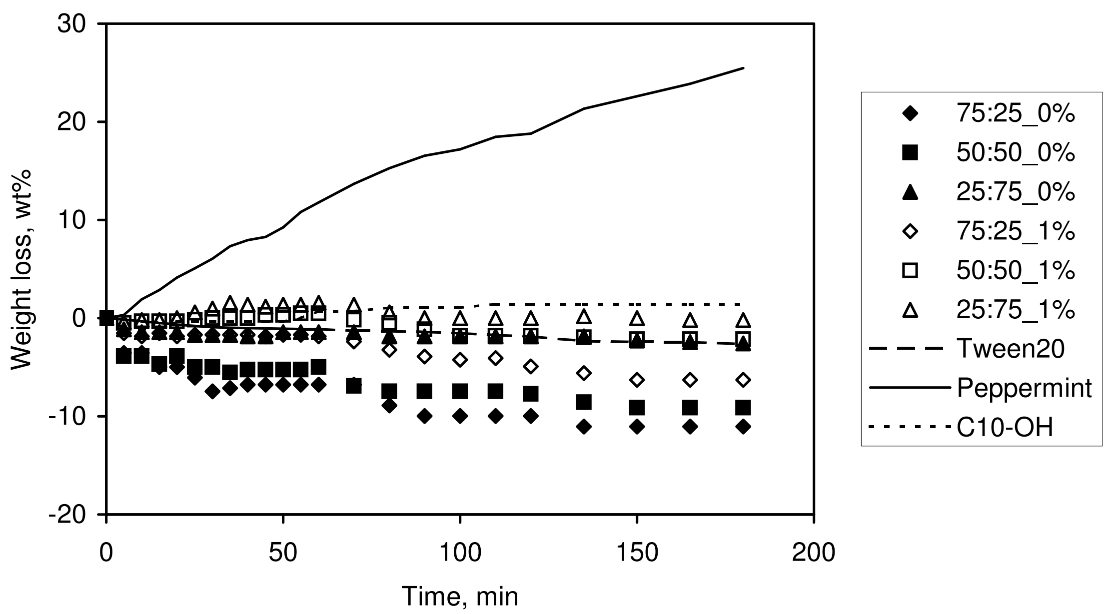

Fig. 3. Percentage of weight loss of different Tween20:C10-OH weight ratios at 0% and 1% peppermint (Tween20:C10-OH_1%) at 87% RH.

Tween20:C7-OH systems with 1% (wt/wt) peppermint were dramatically reduced as compared with those of pure peppermint and Tween20:C7-OH mixtures (without peppermint). Figure 2 shows the difference in percentage weight loss between the two systems and the pure peppermint. This means that the evaporation of peppermint as well as Tween20:C7-OH mixtures are reduced by adding peppermint into mixed Tween20:C7-OH systems. The interactions between peppermint, Tween20 and C7-OH molecules could lead to formation of stable aggregation structures such as micellar or microemulsions, which reduces evaporation of the individual component mixture.

Molecular interaction of Tween20:C10-OH system is stronger than Tween20:C7-OH system since the hydrocarbon chain-length of C10-OH is longer than the C7-OH. Consequently, all weight ratios (25:75, 50:50 and 75:25) of Tween20:C10-OH systems have lower evaporation rates than both the pure Tween20 and C10-OH. It was believed that surfactant association occurred with the assistance of C10-OH, thus, reducing the evaporation rate of C10-OH, particularly at high surfactant concentrations (75:25 and 50:50 wt ratios). However, no or low evaporation of the mixture was noted in the presence of peppermint (see Fig.3). As explained earlier in Tween20:C7-OH system, peppermint played an important role in changing the evaporation profile of a system. In Tween20:C10-OH system, the peppermint molecules might be located at the palisade layer of the surfactant aggregation structure. Another possibility is that peppermint is involved in the aggregation of the component mixtures that leads to the formation of inverse micelle or w/o microemulsion. These phenomena suppressed the evaporation of component mixture, inclusive of the peppermint.

Tween20:C12-OH system exhibited similar behaviour as Tween20:C10-OH system, where the evaporation profile is lower than for pure Tween20. It was believed that this system exhibited the same phenomena as Tween20:C10-OH system. The formation of surfactant aggregate with C12-OH has the ability to reduce the evaporation rate of peppermint with the assumption that the peppermint molecule is either located at the palisade layer of the aggregate structure or participates in the association of the surfactant.

Conclusion

From this study, we observed that the evaporation rate of Tween20:alcohol systems decreased with the increase of hydrocarbon chain-length of the alcohol molecule. The high weight ratio of Tween20:alcohol reduced the evaporation of the system. Evaporation of Tween20:alcohol mixture as well as peppermint were reduced in the presence of 1% peppermint, where the longer the hydrocarbon chain-length of the alcohols the lower the evaporation of the mixture. It is believed, for systems with longer alcohol chain-length, that the peppermint molecule is located at the palisade layer of the surfactant aggregation structure.

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