Development and Evaluation of Dapsone Loaded Topical Liposomes

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ABSTRACT

Topical liposomal drug delivery is becoming promising system with several advantages like skin deposition, controlled release, targeted action and reduced drug quantity etc. Topical treatments are used for various diseases and disorders. Acne vulgaris is a worldwide skin disease. For acne treatments oral, injectable routes are used but topical route is the better route for site delivery. Dapsone, as antibacterial and anti-inflammatory drug has been recommended in topical acne treatment. Multilamellar vesicles (MLV) of dapsone were prepared using conventional thin film hydration method. Optimization techniques were used to determine, formulation with high drug entrapment efficiency and optimum vesicle size. Soya lecithin and cholesterol were used as independent variables. The prepared liposomes were characterized for size, shape, entrapment efficiency, zeta potential, in-vitro drug release (by Franz diffusion cell) and skin deposition. Maximum entrapment was found to be 33.44%. In skin permeation study, liposomal gels resulted in significantly slower drug release than equivalent plain gels. Liposomal gels were found to have 2-3 fold increase in the skin deposition than plain gel, indicating liposome forms depots in skin layers and thus providing a better option to deal with skin-cited acne vulgaris. Amongst different storage conditions (kept for 2 months), the liposomes stored at 2 to 8 °C were found to be most stable, as compare to room temperature and 45 °C.

KEYWORDS: Topical liposome; Acne; Dapsone; Entrapment efficiency; Optimization; Skin deposition.

Introduction

Liposome technology is one of the fastest growing scientific field contributing to areas such as drug delivery, cosmetics, nanotechnology etc. This is due to several advantageous characteristics of liposomes such as ability to incorporate not only water soluble but also lipid soluble agents, specific targeting to the required site in the body and versatility in terms of fluidity, size, charge and number of lamellae (Mozafari, 2005). The first report indicating that topical application of liposomally encapsulated drugs altered drug deposition was presented at the FIP 1979 congress. Mezei and Gulasekhkaram initiated research for utilizing liposomes as drug carriers for topical delivery in the early 1980s. With continuous efforts researchers succeeded in commercializing the liposomal gel for topical delivery of econazole in 1988 by Pevaryl T. M, Cilag, Switzerland. Mezei and Gulasekhkaram reported that topical application of liposomal triamcinolone acetonide for 5 days resulted in a drug concentration in the epidermis and dermis four times higher than that obtained using a control ointment, while urinary excretion of the drug was diminished. Therefore, their results indicated that the use of liposomes might be useful for increased local activity while diminishing the percutaneous absorption of the drug (Egbaria and Weiner. 1990).

Depending upon their solubility and partitioning characteristics, the drug molecules are located differently in the liposomal environment and exhibit different entrapment and release properties. Highly hydrophilic drugs with log P ≤ 0.3, are located exclusively in the aqueous compartments of the liposomes. Highly lipophilic drugs, with log Poct ≥ 5, are entrapped almost completely in the lipid bilayer of the liposomes, drugs with intermediate partition coefficients, i.e., 1.7 ≤ log Poct ≤ 4, pose a major problem because they partition easily between the lipid and aqueous phases and are very easily lost from the liposomes. Such molecules form stable liposomal systems only when they form complexes with the membrane lipids (Gulati et al., 1998). However, the most problematic candidates for liposomal entrapment are the drug molecules which have poor biphasic solubility (e.g. mercaptopurine, azathioprine and allopurinol).

Liposomes are thought to act as “drug localizers” - not only as “drug transporters” (Schmid and Korting, 1996). This is the reason why this study focuses on liposomes as a promising form for topical drug delivery. Although most topical liposome studies have focused on drug deposition into the stratum corneum, a growing number of studies have yielded evidence of follicular delivery via liposomes (Lauer et al., 1996). The demand for localized drug therapy at the level of the hair follicle is very important in several dermatological disorders, such as...
acne, alopecia areata and androgenic hair loss. Because of the similarity in lipid composition to the epidermis, liposomes can also enhance dermal and transdermal drug delivery while reducing systemic absorption (Yang et al., 2009).

Acne vulgaris is a common inflammatory pilosebaceous disease. It is a skin condition in which bacteria or something else has irritated the skin and caused it to develop sores. The rationale for the use of liposomes in the topical delivery for acne treatment is that liposomes have shown the potential to target pilosebaceous structures and hence they can be employed for efficient treatment of hair follicle-associated disorders, such as acne. Liposome can directly fuse with membrane of causative microbes in acne and release the drug. Skalko et al., prepared multilamellar liposomes of clindamycin hydrochloride employing either lecithin and cholesterol or Hostaphat KW (Hoechst) and cholesterol for the treatment of acne vulgaris (Date et al., 2004). In vitro diffusion studies on the Hostaphat liposomes showed a sustained release of the drug as compared to the lecithin-containing liposomes. Chiara Sinico et al., studied the influence of liposome composition, size, lamellarity and charge on the (trans) dermal delivery of tretinoin (TRA). Obtained results showed that liposomes may be an interesting carrier for tretinoin in skin acne treatment, when appropriate formulations are used (Sinico et al., 2005). Patel V. B. et al., studied a novel topical benzoyl peroxide (BP) gel formulation containing liposomal BP to significantly reduce local irritation relative to its nonliposomal BP gel (plain BP gel) preparation and obtained improved clinical efficacy (almost twofold) in the treatment of acne (Patel et al., 2001). Esposito E et al., studied the release of azelaic acid through liposomal system for topical use in acne (Esposito et al., 2004).

Currently optimization techniques are used widely to determine optimum formulation in minimum experimentations. During a development of a new project one generally experiments by a series of logical steps carefully controlling the variable & changing one at a time until a satisfactory result is produced (Banker and Rhodes, 2002).

Dapsone is used topically in acne vulgaris as antibacterial and anti inflammatory agent. Dapsone was chosen for encapsulation within the phospholipid bound closed lamellar systems in order to explore its potential for topical application. The aims of this study were to develop liposome enriched with Dapsone for topical delivery, perform in vivo permeation and skin deposition studies through rat skin, optimization techniques were used to minimize the experiments and find promising formulation.

Materials and Methods

Materials

Dapsone was obtained from Cipla, Mumbai. Carbopol-934 were gifted by Research Lab, Mumbai. Chloroform and methanol were purchased from Thomas Baker and Loba Chemie. Soya lecithin was obtained from Hi Media Laboratories Pvt. Ltd. and cholesterol was obtained from Loba Chemie. The other chemicals were of analytical reagent grade.

Preparation of liposome

Aqueous liposomal formulations were prepared by conventional lipid film hydration method. Different weight ratio of phospholipids: cholesterol were weighed and dissolved in chloroform: methanol mixture (2: 1 v/v) in 250 ml round bottom flask. A thin film was formed on the inner side of round bottom flask by evaporating organic solvent under vacuum in rotary evaporator at 45-50 °C. Subsequently, the flask was kept overnight under vacuum to ensure the complete removal of residual solvent. The dry lipid film was hydrated with 20 ml phosphate buffer solution (pH 7.4) containing dapsone, at a temperature of 60 ± 2 °C for 45 min including initial vortexing at high rpm for 2 min. The dispersion was left undisturbed at room temperature for 2-3 hr to allow complete swelling of the lipid film and hence to obtain vesicular dispersion.

Factorial design

Amount soya lecithin and cholesterol are found to be critical in preparation and stabilization of liposomes and hence both were selected as variables in the factorial designs. To study the effect of variables on liposome performance and characteristics, different batches were prepared using the 3² factorial design approaches. Amount of phosphatidylcholine and cholesterol were selected as two independent variables. Vesicle sizes and entrapment efficiency (EE) were selected as dependent variables. Values of all variables and batch codes are shown in Table 1. Obtained data were subjected to multiple regression analysis using design expert 0.8 software and obtained data were fitted in following equation

\[ Y = b_0 + b_1X_1 + b_2X_2 + b_{11}X_1X_1 + b_{22}X_2X_2 + b_{12}X_1X_2 \]

TABLE 1
Formulations as per 3² Factorial design.

<table>
<thead>
<tr>
<th>Formulation</th>
<th>Dapsone (mg)</th>
<th>Soya lecithin (mg)</th>
<th>Cholesterol (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP1</td>
<td>20</td>
<td>80 (-1)</td>
<td>20 (-1)</td>
</tr>
<tr>
<td>LP2</td>
<td>20</td>
<td>80 (-1)</td>
<td>30 (0)</td>
</tr>
<tr>
<td>LP3</td>
<td>20</td>
<td>80 (-1)</td>
<td>40 (1)</td>
</tr>
<tr>
<td>LP4</td>
<td>20</td>
<td>90 (0)</td>
<td>20 (-1)</td>
</tr>
<tr>
<td>LP5</td>
<td>20</td>
<td>90 (0)</td>
<td>30 (0)</td>
</tr>
<tr>
<td>LP6</td>
<td>20</td>
<td>90 (0)</td>
<td>40 (1)</td>
</tr>
<tr>
<td>LP7</td>
<td>20</td>
<td>100 (1)</td>
<td>20 (-1)</td>
</tr>
<tr>
<td>LP8</td>
<td>20</td>
<td>100 (1)</td>
<td>30 (0)</td>
</tr>
<tr>
<td>LP9</td>
<td>20</td>
<td>100 (1)</td>
<td>40 (1)</td>
</tr>
</tbody>
</table>

Where \( Y \) is the dependent variable, \( b_0 \) is the arithmetic average of all the quantitative outcomes of nine runs. \( b_1, b_2, b_{12} \) are the estimated coefficients computed from the observed experimental response values of \( Y \) and \( X_1 \) and \( X_2 \) are the coded levels of the independent variables. The interaction term \( (X_1X_2) \)
shows how the response values change when two factors are simultaneously changed. The polynomial terms ($X_{12}$, $X_{22}$) are included to investigate nonlinearity.

**Evaluation of liposomes**

All LP1-LP9 formulations were evaluated for entrapment efficiency and vesicle size. Then optimization was applied based on results obtained and then optimized batch were finalized. This optimized batch was studied for *in vitro* skin diffusion and skin retention study.

**Optical microscopy**

The entire prepared liposomes were observed under binocular compound microscope (Optics) at 40X and 10X magnification for studying the vesicle size and shape (Glavas et al., 2005).

**Entrapment efficiency**

The liposomal suspension was centrifuged (Remi) at 3,000 rpm for 15 min to pelletize the unencapsulated drug. The supernatant was centrifuged (Remi Minicentrifuge) at 11,000 rpm to pelletize the drug loaded liposomes. The pellet was then treated with methanol to disrupt the liposomes. The vesicles were broken to release the drug, which was then estimated for the drug content. The absorbance of the drug was noted at 291 nm. The entrapment efficiency was then calculated using following equation (Patel et al., 2009).

\[
\text{Entrapment efficiency} = \frac{\text{Entrapped drug}}{\text{Total drug added}} \times 100
\]

**Vesicle size and size distribution**

The mean vesicle size and vesicle size distribution of the optimized batch were obtained by particle size analyzer (Sympatec HELOS, Germany H1004). The instrument measures the vesicle size and its distribution based on the laser diffraction theory. The sample was stirred using a stirrer before determining the vesicle size. The vesicle dispersions were diluted about 100 times in the deionized water. Diluted liposomal suspension was added to sample dispersion unit containing stirrer and stirred at high speed in order to reduce inter particles aggregation and laser beam was focused

**Determination of zeta potential**

Charge on drug loaded vesicles surface was determined using Zetasizer version 6.12 (Malvern Instruments, Malvern, UK). Analysis time was kept for 60 sec and average zeta potential and charge on the liposome was determined. Dispersion of liposome in phosphate buffer was used for analysis. Temperature were kept at 25 °C and 12 runs were carried out.

**Scanning electron microscopy**

The morphology of the liposomes was determined using a scanning electron microscope (JSM-7600F, Japan).

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**In-vitro skin permeation studies**

*In vitro* skin permeation studies were performed using modified Franz diffusion cell. It was carried out using abdominal skin of Albino Wister rat (Jithan and Swathi, 2010). Experiment was carried out with prior permission and under the guidelines of CPCSEA. Rats were sacrificed by exposing to excess chloroform. To the abdominal skin, depilatory (Vitt, India) was applied and kept for 10 min to remove the hair from the skin. Dermis part of the skin was wiped 3 to 4 times with a wet cotton swab soaked in isopropanol to remove any adhering fat material. After 10 min of application, skin was washed with water. Skin was excised from rat with scalpel and fatty layer was removed by keeping the skin in warm water at 60 °C. After 2 min, fatty layer was peeled off gently and skin was washed with water and kept for saturation in phosphate buffer saline pH 7.4 for about 30 min before it was used for permeation studies. Fresh skin was used every time (Mourtaste S et al., 2007).

**Preparation of gel**

0.5% and 1% carbopol gel were prepared adding 100 mg and 200 mg carbopol 934 in 20 ml distill water respectively. Liposomes containing Dapsone from optimized batch (LP9) were mixed into the 0.5% and 1% (w/w) carbopol hydrogel by an electrical mixer 25 rpm for 5 min to get Dapsone liposomal gels. Plain gel contains equivalent quantity of drug as that of liposome.

The skin was prepared by mounting on the receptor chamber with cross-sectional area of 4.32 cm$^2$ exposed to the receptor compartment of Franz diffusion cell. Receptor compartment was filled with phosphate buffer 7.4 pH. The gel was applied uniformly on dorsal side on rat skin and donor compartment was placed. Samples were withdrawn at 1 hr interval.

**Skin deposition study**

For determination of drug deposited in skin, cell was dismantled after a period of 8 hr and skin was carefully removed from the cell. The gel applied on skin surface was swabbed first with phosphate buffer pH 7.4 and then with methanol. The procedure was repeated twice to ensure no traces of formulation are left onto skin surface (Agrawal and Katare, 2002). The skin was then cut into small pieces and kept in methanol to extract the drug present in skin for 24 hr. Then it was analyzed spectrophotometrically at 291 nm after suitable dilution and filtration.

The ability of vesicles to retain the drug (i.e., drug retentive behavior) was assessed by keeping the liposomal suspensions and liposomal gel at three different temperature conditions, i.e., 4-8 °C (Refrigerator; RF), 25 ± 2 °C (Room temperature; RT), and 45 ± 2 °C for a period of 60 days. Samples were withdrawn periodically and analyzed for the drug content and particle size for liposomal suspension in the manner described under entrapment efficiency and particle size distribution studies.
Results and Discussion

Optical microscopy

Liposomes were studied under 10X and 40X binocular microscopes. Multilamellar vesicles were seen. Figure 1a and 1b shows the images of liposomes at 10X and 40X magnification respectively.

Entrapment efficiency

Entrapment of Dapsone in liposomes was determined using the method elaborated in experimental part. Table 2 shows the result of thesees determination. The percentage entrapment efficiency of different liposomal batches of $3^2$ full factorial designs were found to be between ranges of 14.75% to 33.44%. The maximum entrapment was observed in batch LP 9 i.e., 33.74%. This indicates the high concentration of phosphatidylcholine and cholesterol leads to high entrapment, hence less drug leakage.

<table>
<thead>
<tr>
<th>Formulation</th>
<th>% Entrapment efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP1</td>
<td>26.35 ± 1.35</td>
</tr>
<tr>
<td>LP2</td>
<td>25.14 ± 0.98</td>
</tr>
<tr>
<td>LP3</td>
<td>19.03 ± 2.43</td>
</tr>
<tr>
<td>LP4</td>
<td>14.75 ± 1.16</td>
</tr>
<tr>
<td>LP5</td>
<td>22.31 ± 3.71</td>
</tr>
<tr>
<td>LP6</td>
<td>20.16 ± 1.66</td>
</tr>
<tr>
<td>LP7</td>
<td>16.10 ± 0.41</td>
</tr>
<tr>
<td>LP8</td>
<td>23.82 ± 4.0</td>
</tr>
<tr>
<td>LP9</td>
<td>33.44 ± 0.29</td>
</tr>
</tbody>
</table>
Vesicle size and size distribution

The vesicle size and size distribution of liposomes containing Dapsone were found in between 0.8 µm to 1.39 µm. (Table 3).

<table>
<thead>
<tr>
<th>Formulation</th>
<th>Vesicle size (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP1</td>
<td>1.0 ± 0.072</td>
</tr>
<tr>
<td>LP2</td>
<td>1.16 ± 0.214</td>
</tr>
<tr>
<td>LP3</td>
<td>1.19 ± 0.043</td>
</tr>
<tr>
<td>LP4</td>
<td>1.09 ± 0.104</td>
</tr>
<tr>
<td>LP5</td>
<td>1.12 ± 0.110</td>
</tr>
<tr>
<td>LP6</td>
<td>1.39 ± 0.062</td>
</tr>
<tr>
<td>LP7</td>
<td>0.8 ± 0.027</td>
</tr>
<tr>
<td>LP8</td>
<td>1.15 ± 0.148</td>
</tr>
<tr>
<td>LP9</td>
<td>1.18 ± 0.021</td>
</tr>
</tbody>
</table>

Optimization data analysis

Liposomes were prepared using film hydration technique and method was found to be well suited for the production of liposomes without aggregation. Responses of different batches were obtained by using factorial design.

Determination of EE is an important parameter in case of liposomes as it may affect the drug release and skin depositions. EE is expressed as the fraction of drug incorporated into liposomes relative to total amount of drug used. In the present study, to understand the effect of lipid concentration on vesicle size, coefficient observed for EE fitted in equation. 

\[ \text{Entrapment efficiency} = 20.73 + 0.29X_1 + 2.59X_2 + 6.19X_1X_2 + 5.05X_1^2 - 0.13X_2^2 \]

A positive correlation was observed for both variables X1 (Soy lecithin) and X2 (Cholesterol). Thus with increase in the concentration of lecithin and CH entrapment efficiency found to be increased.

From the number of reports, it was observed that the size and size distribution of the liposome determines there in vivo or ex-vivo performance. There are some reports, which showed the effect of liposome size on the drug release as well as drug deposition in the skin. To understand the effect of lipid concentration on vesicle size, coefficient observed for liposome size fitted in Eq. 

\[ \text{Particle size} = 1.23 - 0.030X_1 + 0.14X_2 + 0.057X_1X_2 - 0.13X_1^2 - 0.042X_2^2 \]

The 3D response surface (Figure 2) predicts high entrapment at maximum amount of soya lecithin and cholesterol level, hence showing LP9 batch as optimize batch. 3D response surface image shows LP9 batch (Figure 3) have optimum region for particle size. Table 4 shows the predicted values of entrapment efficiency and particle size which was closer to LP9 batch.

Particle size distribution, Polydispersity index and Zeta potential

Figure 4 shows the size distribution of the optimized liposomal batch (LP9) from 3² factorial designs. It was found to be approximately 1176.72 nm. The polydispersity index measures the size distribution of the nanoparticles population. Polydispersity index was found to be 0.893, hence obtained liposome population have narrow size distribution. The value of zeta potential was found to be -16.2 mV for optimized batch. It indicates prepared liposome have sufficient charge to avoid aggregation of vesicles.

Fig. 2. 3D response surface for entrapment efficiency.

Fig. 3. 3D response surface for particle size.
TABLE 4
Confirmation Report for optimization.

<table>
<thead>
<tr>
<th>Response</th>
<th>Prediction</th>
<th>Std Dev</th>
<th>SE (n = 1)</th>
<th>95% PI low</th>
<th>95% PI high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrapment Efficiency</td>
<td>32.3744</td>
<td>2.00793</td>
<td>2.69808</td>
<td>23.7879</td>
<td>40.9609</td>
</tr>
<tr>
<td>Particle size</td>
<td>1.22528</td>
<td>0.0973301</td>
<td>0.1307830</td>
<td>0.809066</td>
<td>1.64149</td>
</tr>
</tbody>
</table>

 Transmission electron microscopy and scanning electron microscopy

The scanning electron micrograph of the liposome indicates a spherical morphology and size in the nano dimensions. Figure 5 shows the image at 15000x indicating spherical appearance of liposomes.

In-vitro skin permeation studies

Results obtained from in-vitro drug permeation studies conducted with liposomal and non-liposomal gels of Dapsone are shown in figure 6. Significant changes in the skin permeation of Dapsone have been observed with liposomal formulations and plain carbopol gel.

The amount of Dapsone permeated in eight hours was found to be 57.29% and 54.62 from 0.5% and 1% liposomal gel, respectively, whereas 77.51% and 71.66% of the drug permeated in case of 0.5% and 1% plain Dapsone gel, respectively.

Higher values of flux obtained with 0.5% plain gel 8.41 g/cm²/hr, and 1% plain gel 5.28 μg/cm²/hr, than that obtained with 0.5% liposomal gel 3.06 μg/cm²/hr, and 1% liposomal gel 2.92 μg/cm²/hr. This indicates that liposomal gel releases drug slowly and allow drug to retain in to skin. Table 5 shows the cumulative drug permeated, permeation flux, % drug retained in the skin after 8 hr.
Skin deposition study

Table 5 shows the result obtained for drug deposition study after 8 hr. In skin deposition studies the amounts of Dapsone retained were 4.17% (0.5% plain gel), 13.89% (0.5% liposomal gel) and 11.54% (1% plain gel), 20.58% (1% liposomal gel).

Results of this study clearly depict (Figure 7) that the amount of drug retained in the skin was considerably higher in case of liposomal preparations, than with non-liposomal.

These results show the influence of vesicular systems and non vesicular formulations on the penetration, retention, and permeation tendencies of the drug molecules. The study data show that liposomal systems can make the drug molecules accessible within the skin layers. The high retention but reduced permeation of the drug in vesicular systems can be attributed to intrinsic liposome–skin interaction behavior. This conclusion compares favorably with an earlier study that showed that the drug associated with liposome bilayers within the liposomal compartments can be better routed into the skin (Agarwal et al., 2001). Other studies have shown that liposomal ambience may help modify the permeability characteristics of the stratum corneum, and the systems keep the drug molecules within the skin layers so that their skin-substantivity is high (Agrawal and Katare, 2002).

![In-vitro drug permeation study.](image)

**TABLE 5**

Permeation flux and % drug retained in skin.

<table>
<thead>
<tr>
<th>Formulation</th>
<th>% Cumulative drug permeated</th>
<th>Permeation flux μg/cm²/hr</th>
<th>% Drug retained in the skin</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5% Plain gel</td>
<td>77.51 ± 0.56</td>
<td>8.41 ± 0.49</td>
<td>4.17 ± 0.67</td>
</tr>
<tr>
<td>0.5% Liposomal gel</td>
<td>57.29 ± 0.87</td>
<td>3.06 ± 0.16</td>
<td>13.89 ± 0.84</td>
</tr>
<tr>
<td>1% Plain gel</td>
<td>71.66 ± 1.45</td>
<td>5.28 ± 0.29</td>
<td>11.54 ± 0.59</td>
</tr>
<tr>
<td>1% Liposomal gel</td>
<td>54.62 ± 0.91</td>
<td>2.92 ± 0.44</td>
<td>20.58 ± 0.87</td>
</tr>
</tbody>
</table>

![Percentage Drug retention profile.](image)
The liposomal phospholipids (also one of the natural constituent of skin lipids) helped generating and retaining the required physico-chemical state of the skin to produce the depot effect for drug molecules. Thus, the liposomal Dapsone formulation, with desired characteristics for topical administration, could be successfully prepared. The formulated Dapsone liposomes have shown an appreciably enhanced retention of drug molecules in the skin and thus it is helpful in skin disorders like acne effectively.

**Stability studies**

Stability studies of two-months were conducted for optimized LP9 batch with respect to the liposomes’ ability to retain an entrapped drug during a defined time period. Batch at 45 ± 2°C showed high drug leakage and entrapped drug was found to be only 15.28%. Batch at 25 ± 2°C and refrigeration temperature (2-8 °C) shown less leakage and entrapped drug was found to be 28.41% and 31.28% respectively. Drug leakage at elevated temperatures may be resulted due to of chemical degradation (oxidation and hydrolysis) of lipids in the bilayers, leading to defects in membrane packing (Yadav et al., 2011).

Thus, earlier reports of the low-temperature stability of liposomal products may be attributed to the gel-state lipid membranes that help to hold drug molecules in place and thus show high drug retention. Slight increase in vesicle size occurred due to aggregation of liposomes during storage. Table 6 shows the stability results and figure 8 shows the effect of storage temperature on drug leakage from liposome.

**TABLE 6**

<table>
<thead>
<tr>
<th>Temperature</th>
<th>%Entrapment efficiency</th>
<th>Vesicle size (µm)</th>
<th>Appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-8 °C</td>
<td>31.28</td>
<td>1.26</td>
<td>White dispersion</td>
</tr>
<tr>
<td>Room Temperature</td>
<td>28.41</td>
<td>1.33</td>
<td>White dispersion</td>
</tr>
<tr>
<td>45 °C</td>
<td>15.28</td>
<td>1.35</td>
<td>White dispersion with sedimentation</td>
</tr>
</tbody>
</table>

**Fig. 8.** Percentage Entrapped drug remaining after 2 months stability study.

**Conclusions**

Overall results obtained during this work have shown that liposomes could prove interesting carrier for Dapsone in skin disease treatment, when appropriate formulations are used. Effectiveness of drug would be increased with liposomal system. Dapsone molecules could be successfully entrapped in liposomes with reasonable drug loading. These findings have been seen to support the improved and localized drug action in the skin, thus providing a better option to deal with skin-cited problems. Hence from results obtained it can be concluded that liposomal gel containing Dapsone has potential application in topical delivery in acne vulgaris.

**Acknowledgement**

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**References**


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