Effects of Polymer Entrapment of Prunus Spinosa Fruit Extract on its Cosmetic Efficacy

Slobodanka Tamburic
Cosmetic Science, London College of Fashion, University of the Arts, London

Received: January, 2006.

Key words: Prunus spinosa; Propylene glycol extract; Skin hydration; Net elasticity; Allyl methacrylate crosspolymer;

Summary

The aim of this paper was to find out whether the entrapment of herbal extract into the polymeric ‘reservoir’ system affects its skin efficacy.

Propylene glycol extract of Prunus spinosa (blackthorn, sloe, wild plum) fruit was obtained by a triple percolation process and characterised by relative density, refractive index, pH and the content of dry matter and tannins.

The extract was incorporated into an o/w formulation, based on a non-ethoxylated emulsifier, in the concentration of 5%w/w. In addition, two modifications of the polymer delivery system based on allyl methacrylate crosspolymer were prepared, containing the extract/polymer ratio of 1:0.5 and 1:1, respectively. A short-term moisturising study of four samples (placebo cream, cream with 5% extract and two creams with 5% extract in different ratios of polymer) against a non-treated control and 10% glycerol solution was performed. A long-term moisturising study using the samples with and without polymer was then carried out, accompanied with the measurement of skin biomechanical properties.

There was no evidence of significant difference in the moisturising properties of any of the three samples containing blackthorn extract in the short-term study. A two-week study revealed a pattern of slow developing, but steadily increasing effect of the sample containing the polymer entrapped extract. Similar conclusion was drawn from the cutometer results, based on the changes of the ratio parameter R5 (net elasticity).

Overall, this study has not revealed conclusive evidence that polymer entrapment of blackthorn fruit extract provides better skin performance than a non-entrapped extract. However, it is clear that the process did not hinder the moisturising potential of the herbal extract, which is an important fact when delivery system is used for the purpose other than increased skin efficacy (e.g. for stability, sebum control or odour-masking effect).

Riassunto

Lo scopo di questo lavoro è di verificare se l’intrappolamento di un estratto vegetale da parte di un sistema polimerico sia in grado di esaltare l’efficacia. L’estratto glicolico del frutto del Prunus spi-
Effects of Polymer Entrapment of Prunus Spinosa Fruit Extract on its Cosmetic Efficacy

Prunus spinosa, è stato ottenuto da un triplo processo di percolazione effettuato con il glicopropilenico e caratterizzato dalla densità relativa, dall’indice di rifrazione, dal pH e dal contenuto di materia secca e tannini.

L’estratto è stato incorporato in una emulsione O/A ottenuta con un emulsionante non etossilato alla concentrazione del 5% p/p. Inoltre sono state preparate due varianti del sistema polimerico basato su un crosspolimero allil metacrilato, contenente l’estratto/polimero nei rispettivi rapporti 1:0,5 e 1:1. Per determinare il potere idratante dell’estratto è stato condotto uno studio a breve termine su quattro campioni (crema placebo, crema con il 5% dell’estratto e due altre creme con il 5% di estratto e con diversi rapporti di concentrazione del polimero) confrontati con un controllo non trattato e con un controllo trattato con una soluzione di glicerolo al 10%.

Per determinare il potere idratante a lungo termine sono stati utilizzati campioni con e senza polimero controllandone anche le proprietà biomeccaniche nei confronti della pelle.

A breve termine tutti i risultati ottenuti per l’idratazione cutanea non sono tra di loro significativi. Con lo studio condotto per due settimane si è verificato un leggero incremento dell’idratazione con il campione che conteneva l’estratto intrappolato nel polimero. Analoghi risultati sono stati riscontrati nei confronti dell’elasticità. Nell’insieme lo studio non ha portato a conclusioni evidenti circa l’efficacia dell’estratto intrappolato dal polimero.

E’ comunque chiaro che questo studio non esclude il potenziale effetto idratante esplicato di per sé dal Prunus spinosa.
INTRODUCTION

Prunus spinosa (blackthorn, sloe, wild plum) is a wild plant, used in traditional medicine and in cooking. The fruit, exceedingly astringent and rich in pectin, is usually used in jellies, syrups, conserves and as flavouring for sloe gin and other liqueurs. In addition, the pulped ripe fruit is used cosmetically in making astringent face-masks (1). In our recent study, an attempt was made to assess other potential cosmetic benefits of this plant, including its skin hydration potential (2). It was shown that the inclusion of Prunus spinosa extract in an o/w cream did have significant effect on the skin hydration state and it was related to the presence of water-binding oligosaccharides (2).

Plant extracts are known to have problematic stability profiles, due to the number and types of organic components originating from plant material. One approach to increase stability, and possibly add other benefits to the formulation, is the use of novel delivery systems. There is a wide choice of delivery systems for use in cosmetics, especially for lipophilic active ingredients (e.g. 3,4). However, the choice of delivery systems for hydrophilic actives (e.g propylene glycol extracts) is quite limited. A relatively new microparticulate delivery system based on allyl methacrylate crosspolymer is said to be suitable for both hydro- and lipophilic materials, including liquids (5). The system consists of clusters of spherical particles, with medium diameter of about 30μm, which are agglomerated together to form the porous exterior surface and a hollow interior. It is claimed to provide a 'reservoir' for the active, from which the active is released slowly, through a combination of friction and diffusion (6). This microparticulate system is potentially beneficial in improving the stability and extending the release of active ingredients, providing sebum control and increasing emulsion stability through secondary thickening (6).

The aim of this study was to assess whether this delivery system was suitable for the incorporation of propylene glycol extract of Prunus spinosa and whether and to which extent the polymer entrapment affected its skin efficacy. The skin performance was evaluated by the changes in skin hydration parameters on both short and long-term bases, which in the long-term study was accompanied by the measurement of skin biomechanical properties.

MATERIALS AND METHODS

Materials

Prunus spinosa fruit extract

The fruit of blackthorn - Prunus spinosa (L.), Rosaceae was used to make the polyol/water based extract. Propylene glycol used was 45% w/w aqueous solution. The extract was obtained at ambient temperature by a percolation method, using a plant:extract ratio of 1:2 (7). This is an exhaustive extraction method, performed in three stages, whereby only the most concentrated percolates of each stage are used and combined to obtain the final product. The resulting extract was intensely red. Prunus spinosa (PS) extract was then characterised by relative density (1.0971), refractive index (1.3621), pH (4.09), and the contents of dry matter (6.39%) and tannins (21.85%), as reported in the previous study (2).

Test formulations

Test samples were of o/w cream type, based on a non-ionic, non-ethoxylated emulsifier - Eumulgin® VL75, INCI: lauryl glycoside (and) polyglyceryl-2 dipolyhydroxystearate (and) glycerine (Cognis, Germany). In addition, the following materials were used in the preparation of the samples: isopropyl myristate, octyldode-
canol (Eutanol®G), caprylic/capric triglycerides (Myritol®318), all supplied by Cognis, and glycerine, propylene glycol, mineral oil, potassium hydroxide and purified water (all of pharmacopoeial quality). Carbomer (Ultraz 10) was supplied by Noveon, USA, while allyl methacrylate crosspolymer (Poly-pore® E200) was obtained by Amcol, USA. All samples were persevered with 0.1% Eyxil® K 100 (5-chloro-2-methyl-3-(2H)-isothiazolone/2-methyl-3-(2H)-isothiazolone/benzylalcohol), supplied by Schulke & Mayr, Germany. The compositions of the test samples are presented in Table I.

**Methods**

**Cream preparation method**

The o/w type cream was obtained by the cold-cold emulsification method, by dispersing 20% w/w of the mixed oil phase into the aqueous phase, using 5% w/w non-ionic emulsifier and 0.6% w/w neutralised polyacrylic polymer as stabilisers. The pH values of the cream samples were within the range of 5.6-5.8.

In all samples, except placebo, Prunus spinosa fruit extract was incorporated in the concentration of 5% w/w, previously found to be effective in increasing skin hydration level (2). When polymer-entrapped extract was used, the extract was firstly mixed with allyl methacrylate crosspolymer in the 1:1 and 1:0.5 ratio, respectively, until a homogeneous paste was obtained. A required amount of the paste was then incorporated into the emulsion. Prunus spinosa fruit extract was always added during the final stage of emulsion preparation, with the stirring speed not exceeding 500 rpm.

**Skin hydration studies**

A total of 27 healthy individuals without the history or clinical signs of dermatological disease, with normal to moderately dry skin, have participated in the two skin hydration studies. The studies were approved by the relevant ethics committee and informed consents were obtained from all volunteers.

**Tab. I**

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>placebo (% w/w)</th>
<th>PS (% w/w)</th>
<th>PS 1:1 (% w/w)</th>
<th>PS 1:0.5 (% w/w)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lauryl Glycoside (and) Polyglyceryl-2</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Dipolyhydroxystearate (and) Glycerine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isopropylmyristate</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Caprylic/Capric triglyceride</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Octyldodecanol</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Mineral oil</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Carbomer</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Glycerine</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>KOH, 10% sol.</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Blackthorn extract</td>
<td>---</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Allyl methacrylate crosspolymer</td>
<td>---</td>
<td>---</td>
<td>5.0</td>
<td>2.5</td>
</tr>
<tr>
<td>Propylene glycol</td>
<td>5.0</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Preservative</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Purified water</td>
<td>Up to 100.0</td>
<td>Up to 100.0</td>
<td>Up to 100.0</td>
<td>Up to 100.0</td>
</tr>
</tbody>
</table>

In Table I, "placebo" refers to the cream without Prunus spinosa fruit extract, "PS" refers to the cream with 5% w/w Prunus spinosa fruit extract, "PS 1:1" refers to the cream with 5% w/w Prunus spinosa fruit extract entrapped in 5% w/w polymeric extract, and "PS 1:0.5" refers to the cream with 5% w/w Prunus spinosa fruit extract entrapped in 2.5% w/w polymeric extract.
**Short-term study**

Nine volunteers (7 female and 2 male, average age 28.7) were recruited for the short-term study. Corneometer CM 825 (Courage & Khazaka, Germany) was used to evaluate skin surface hydration. Corneometer measures changes in skin surface capacitance and expresses the results in relative corneometer units (rcu). The study protocol was designed on the basis of the published guidelines (8).

Three squared sites (3x3cm, 2 cm apart) on each volunteer’s inner forearm were marked using a plastic template, which allowed for the testing of six sites. An experimental design including two controls (a non-treated site and 10% w/w glycerol solution) and four test samples (listed in Table I) was chosen. The room temperature was 21-22°C and the relative humidity 53% throughout the trial.

After 30 minutes of acclimatisation, the baseline values were measured, and each designated area was treated with 2µl/cm² of a test sample (random and balanced distribution among the upper, middle and lower test sites). The test samples were applied with an Eppendorf micropipette and spread homogeneously using the flattened tip of a glass rod. On the basis of our previous results (9), a period of 45 minutes was allowed to elapse before the first measurement was taken. Three corneometer readings of each test site were recorded, with at least 5 seconds between the readings. The change in skin hydration was followed up to two and a half hours.

**Long-term study**

A panel of 18 volunteers (all female, average age 37.8) were recruited and provided with written instructions regarding their role in the study, after which they were asked to sign an informed consent. Volunteers were required to refrain from the use of any moisturising products on their inner forearms for two weeks before the start of the study. The left inner forearm was used as a treatment site, while the contra-lateral site served as a control. Half the panel was treated with the placebo emulsion (treatment A) and the other half with the active product, containing the extract/polymer ratio of 1:1 (treatment B).

The trial was carried out over the period of 16 days, with the volunteers applying a designated treatment twice daily for 2 weeks, followed by a two days regression period. The quantity applied was standardised to one portion obtained by a pump dispenser. Skin hydration tests were performed at baseline, 4 hours after the first application, after the 1st and 2nd week, as well as 2 days after the cessation of the treatment. Measurements were obtained 12 to 16 hours after the last product application, as suggested in the literature (10). No other products were used on each forearm for the duration of the trial.

**Skin biomechanical properties**

In the long-term study, skin visco-elasticity was recorded alongside skin hydration, by means of a suction-based instrument (Cutometer/SEM 575). Measurements were performed according to the manufacturer’s instructions (11), using a 2mm aperture probe and the following parameter settings: 450 mbar, on-time 2 sec, off-time 2 sec, 3 repeats. This was followed by a computer-aided calculation of a series of mechanical parameters, of which net elasticity (R5) was chosen for further analysis.

**Statistical analysis**

The values of all observed parameters are given as means ± SD. Following a positive testing for normality, parametric tests were used in the short-term study. Data were analysed by the one-way within-subjects (repeated measurements) ANOVA, followed by Duncan multiple
range test. Differences between placebo and corresponding active treatments at distinct time points were checked by unpaired Student t-test. Due to significant differences in standard deviations, long-term study results were analysed by a non-parametric Kruskall Wallis test.

**RESULTS**

**Results of the short-term study**

Table II shows the mean corneometer readings for each treatment obtained from 54 test sites (6 sites from each of the 9 volunteers) over 150 min. Student t-test showed that the control site remained statistically unchanged during the study, while all other sites at all time points were statistically significantly higher from baseline. Analysis of variance of each time point has shown that after 45, 90 and 150 minutes the mean readings for the four test sites and the positive control (glycerol 10%) did not statistically significantly differ from each other (p<0.05).

Two graphical representations of the same set of data were presented in Figures 1 and 2. Figure 1 shows the set of mean values from which their respective baseline values have been subtracted. To compensate for both initial and inter-individual differences, a further subtraction from means of their respective control values was carried out and the results presented in Figure 2. Results viewed in this manner indicate some trends, which were not apparent before. For example, after 90 and 150 min, the sample with 5% extract (without polymer) has shown the hydration potential almost identical to the one obtained by 10% glycerol. Out of the two samples with polymer-entrapped extracts, the one with the higher polymer content (PS 1:1) has shown the lowest impact on the skin capacitance, within the given time. These trends were not strong enough to be detected by the above-mentioned ANOVA analysis, most probably due to the low number of participants. It would be of interest to repeat the study with the larger number of volunteers and for a longer time period to elucidate whether these differences really exist and for how long they are detectable.

Further analysis was performed by calculating the difference to control for each treatment in each time point and presenting the results as % increase from control (Figure 4). Non-parametric analysis of this set of data has revealed significantly lower value in the case of polymer-entrapped extract containing cream after 4 hours. However, the significance (p<0.05) was lost after one week and was non-existent after two weeks and also after the two days regression period. The trend of consistent increase in skin hydration achieved by the polymer-entrapped extract was detectable, but not statistically significant after two days. This again may be due to the insufficient number of participants in this study.

<table>
<thead>
<tr>
<th>Sample</th>
<th>baseline</th>
<th>45 min</th>
<th>90 min</th>
<th>150 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>control</td>
<td>37.71±4.12</td>
<td>38.78±3.21</td>
<td>40.17±3.41</td>
<td>40.08±4.02</td>
</tr>
<tr>
<td>placebo</td>
<td>40.59±3.75</td>
<td>60.03±4.05</td>
<td>61.49±4.82</td>
<td>61.16±3.98</td>
</tr>
<tr>
<td>PS</td>
<td>39.06±4.24</td>
<td>60.04±5.55</td>
<td>63.60±3.78</td>
<td>63.09±5.01</td>
</tr>
<tr>
<td>PS 1:1</td>
<td>34.89±3.18</td>
<td>57.36±5.88</td>
<td>58.00±4.50</td>
<td>57.70±4.90</td>
</tr>
<tr>
<td>PS 1:0.5</td>
<td>36.47±2.98</td>
<td>58.28±4.09</td>
<td>60.27±5.06</td>
<td>58.41±4.29</td>
</tr>
<tr>
<td>Glycerol 10%</td>
<td>35.79±3.87</td>
<td>61.57±4.75</td>
<td>63.04±4.90</td>
<td>62.53±5.01</td>
</tr>
</tbody>
</table>
Fig. 1 Short term study: Effect of the extract-polymer ratio on skin capacitance; data expressed as difference to baseline.

Fig. 2 Short term study: Effect of the extract-polymer ratio on skin capacitance; data expressed as difference to baseline and control.
Effects of Polymer Entrapment of Prunus Spinosa Fruit Extract on its Cosmetic Efficacy

Fig. 3 Long term study: Changes in skin hydration over two weeks plus two days regression period; treatment A - 5% extract; treatment B - 5% extract entrapped in polymer 1:1; n = 9 for treatment A and B, respectively.

Fig. 4 Long term study: Changes in skin hydration expressed as % difference from control.
In addition to skin hydration changes, skin mechanical properties, known to correlate with improved skin hydration, were evaluated. Out of the eight R parameters and two F (area) parameters provided by the software, the ratio parameter R5 (net elasticity) was chosen for further analysis.

When shown as difference to control (Figure 5), the net elasticity data revealed similar trend as obtained by skin hydration measurements (Figure 4), except after 4 hours, when the situation was reversed. No statistically significant difference between treatments A and B was found after 1 and 2 weeks. This was also true for the 2 days regression period, although the p value was approaching 0.05.
DISCUSSION

Modern plant extracts (as opposed to traditional ones) are normally ambient infusions, using about 50% aqueous propylene glycol at a herb/extract ratio of 1:10. The extract of Prunus spinosa fruit used in this study was obtained by a pharmacopoeia-based triple percolation method, with the herb/extract ratio of 1:2. This resulted in a much higher concentration of the plant material in the solution, including cosmetic actives, which contributes to its considerable efficacy.

Prunus spinosa is known to be of both medicinal and nutritional interest, with different parts of the plant being evaluated in detail (e.g. 13). However, its cosmetic potential has not been explored systematically. Studies of the composition of the fruit extract have identified flavonoid glycosides, coumarin derivatives, tannins, fruit acids, vitamin C and mono- and oligosaccharides, most of which are of interest in cosmetic formulation.

Short-term moisturiser testing is well established as a useful method for rapid determination of immediate skin effects, but with a disadvantage of insufficient time for full effects to be exerted, especially in the case of ‘therapeutic moisturisers’ (15). Longer-term testing overcomes this problem, while regression methods go a step further by testing residual effects of moisturisers, after the application has been withdrawn. There are many modifications of the original Kingman’s regression method proposed in 1978, which lasted 4-6 weeks. They are based on the same principles, but take much shorter time, with the ultimate development of a one-week mini-regression test (15, 16). For the purpose of this study, an application period of two weeks, followed by a two-day regression period, was chosen. The first measurement was taken 4 hours after the baseline values were measured and the test product applied for the first time, in order to obtain information beyond 150 minutes available from the short-term study.

Formulations chosen for this study were based on a non-ethoxylated emulsifier of a polyglycoside type (Table I). This group of emulsifiers has been proposed as a more favourable alternative to traditionally used polyoxyethylene derivatives in stabilising o/w emulsions, due to their lower lipid depleting effect and smaller alterations of superficial cutaneous proteins. In our previous study, a sample based on polyglycoside type emulsifier has proven to be a superior moisturiser in comparison with three other emulsion bases.

All four samples tested in the short-term study have shown very similar moisturising activity, which was not significantly different from each other or from 10% glycerol (Table II, Fig. 1). Higher concentration of glycerol was avoided, since it is known that the corneometer is less sensitive in the range of very high hydration values (19). Given the same content (10%) of humectants in the formulation, but combined with additional emollients (Table I), it was of interest to find out whether the cream samples would provide better moisturisation than the glycerol solution. It was not found to be the case under the experimental conditions used. Further data analysis, including deduction of the baseline and control values from the test values at each time point (Fig. 2), enabled the differences to become visible, with the sample containing the highest ratio of polymer showing consistently lower values. This finding is in line with the claim that the polymer delivery system provides slow, sustained release of actives (6).

This trend becomes more pronounced when analysing the four-hour values obtained in the long-term study (Fig. 3 and 4). The sample containing free extract (A) have exerted significantly higher skin hydration than the sample containing delivery system (B), indicating that...
the entrapped extract needs some time to get released from its polymer microparticles. It is known that an active is loaded into the allyl methacrylate crosspolymer carrier through a combination of capillary action and its affinity for the polymer matrix (5). Its particle size of 30µm does not allow skin penetration, therefore the polymer and its entrapped content stay on the skin surface. It is also known that lipophilic active materials partition into the interior of the polymer network, while hydrophilic actives stay on the exterior. Both are released through a combination of friction and diffusion, and it is possible (although not tested here) that hydrophilic actives are released faster.

As the time of the study progressed to one and then two weeks, the difference between tested samples started to diminish. Two days after the withdrawal of treatment, the results indicated that the delivery system might have a longer lasting effect (Fig. 4). A new study with larger number of volunteers will have to be performed in order to test this hypothesis. However, the results of the above hydration studies have proven that the polymer entrapment of the Prunus spinosa fruit extract did not adversely affect its moisturising potential.

Assessment of skin biomechanical properties is not a straightforward task, because of the complex interactions between different skin layers. It is generally accepted that the stratum corneum contributes to the overall skin viscoelasticity, albeit less that viable epidermis and possibly dermis (20). The contribution of dermis depends on the load applied (in the case of cutometer, the negative pressure) and the diameter of the probe orifice. Therefore, the measurements of the subtle changes in stratum corneum mechanics, e.g. in response to acute hydration, are relatively insensitive. It was of interest of assess whether or not there was a correlation between skin hydration and biomechanical parameters in a 16-day regression test, and which parameter would be most suitable for this type of study.

It is well established that the deformation parameters obtained by cutometer (e.g. maximum extensibility \(U_I\), immediate deformation \(U_e\) and immediate recovery \(U_r\)) are dependent on the skin thickness. Since the volunteers involved in the study were not an age-homogeneous group, it was clear that either a ratio or an area parameter should be used. Out of 9 ratio parameters offered by the software, the instrument manual stresses the importance of \(R_2\) (gross elasticity), a ratio between the maximum amplitude and the ability of re-deformation (11). However, the ratio parameter \(R_5\) (net elasticity) was shown to be independent of the skin thickness (21) and as such already used for comparative purposes (e.g. 22). Net elasticity is defined as \(U_r/U_e\) - a ratio between immediate recovery and immediate deformation.

In our regression study, net elasticity has shown a good correlation with the skin hydration data (Figs. 4 and 5), except for the 4-hour measurement. Short-term biomechanical effects are known to be difficult to correctly identify and it is possible that this one was an artefact due to the product residue. However, an absence of significant difference between the two test samples after both one and two weeks, as well as a higher response obtained by the delivery system after 2 days of regression, were mirrored by cutometer tests. These results confirmed the suitability of net elasticity (\(R_5\)) as a biomechanical parameter to be used alongside skin hydration measurements. They also confirm that the polymer entrapment of the Prunus spinosa extract does not negatively affect the products biomechanical efficacy.

**CONCLUSION**

The aim of this study was not to directly assess cosmetic efficacy of the Prunus spinosa extract, since it was an object of our previous study (2),
which has shown its high moisturising potential. Considering the variety of possible cosmetic actives in the extract (including antibacterial and free radical scavenging materials), it was of interest to explore the ways of their protection when incorporated in a finished cosmetic product. A microparticulate delivery system based on allyl methacrylate crosspolymer was used and its effects on the cosmetic efficacy of the Prunus spinosa extract were assessed. It was shown that the polymer entrapment of the extract did not adversely affect its skin performance and that it was suitable as a delivery system. In addition, an indication of sustained release and longer lasting effect on both skin hydration and biomechanical properties was detected in the case of polymer entrapped extract. This hypothesis will have to be tested with larger number of volunteers in order to establish whether differences in skin performance are statistically significant.

ACKNOWLEDGEMENTS

The author wishes to thank the University of the Arts, London for the provision of the sabbatical research fellowship and Ms. Senait Tewolde for technical help and assistance.
References


6) AMCOL Health & Beauty Solutions (2002) Technical data and MSDS for Poly-Pore® E200


**Author Address:**

Slobodanka Tamburic, BPharm, PhD
Cosmetic Science
London College of Fashion
University of the Arts
20 John Prince's Street
London W1G OBJ
Email: d.tamburic@fashion.arts.ac.uk