Formation and application of citronella oil and lemon grass finish on Rambouillet wool and assessment of their physical properties and durability

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ABSTRACT: Wool is one of the most useful of all textile fibers. Not only it is obtainable in very large quantities but also it is warm fiber with a soft handle and is thus particularly suitable for a variety of garments. Under the present study, pure Rambouillet wool fabric was used for the application of microcapsules which were made through two techniques i.e. simple and complex coacervation technique. Gums of two types (gum acacia & sodium alginate) and two types of oils (citronella & lemon grass oil) were used as wall and core materials respectively. It was found that after application of finish fabric weight, fabric thickness, bending length and thermal conductivity of the treated wool samples were increased. It was noticed that best results for the durability of fragrance in Rambouillet fabric were obtained from the fabric specimen which were microencapsulated with gum acacia + lemon grass oil by using simple coacervation technique, followed by sodium alginate + lemon grass oil by using complex coacervation technique.

Key words: Coacervation technique, microencapsulation, wool

Wool is one of the oldest and most universally used in textile industry, wool obtained from sheep is commercially the most important due to its inherent unique properties, thus wool plays a pivotal role in textile industry. The special features of wool fiber which make it supremely valuable as a textile fiber of outstanding importance are warmth, excellent resiliency, water repellency, flame retardency moisture absorption capacity and ability to well drape etc. Therefore rambouillet wool was selected for the present study.

The Rambouillet is the largest of fine wool sheep. Rambouillet ewes are crossbred extensively with medium wool and long- course- wool rams to gets ewes with having, attractive medium wool.

Aromatherapy is a generic term that refers to any of the various traditions that make use of essential oils sometimes in combination with other alternative medical practices and spiritual beliefs. Popular uses of these products include massaging products, medicine or any topical application that incorporates the use of essential oils. Aromatherapy does not cure conditions, but helps the body to find a natural way to cure itself and improve immune response.

The fragrant compounds and the essential oils are volatile substances. As the second skin of the human body, all types of textile are excellent media for transferring fragrant compounds and may be used by people according to their preference for them.

The most difficult task in preparing the aromatherapy textile is how to prolong its odour for lifetime. The key to aroma therapeutic textile is how to make microcapsules of fragrance compounds and essential oils without omitting any ingredient in order to ensure its pharmaceutical effects. In addition, using a low temperature polymer binder to attach perfumed microcapsules to the surface of the textile is also an important part of preparing an aroma therapeutic textile. At the same time, durability in laundering and tactile properties i.e. soft handle should be carefully considered. Microencapsulation is an effective technique to solve this problem. Therefore microencapsulation technique is becoming popular to be used for aromatherapy.

MATERIALS AND METHODS

Rambouillet (pure wool) fabric was selected for the present study was a woven fabric (43 ends & 41 picks/inch). Application of finish was done through microencapsulation techniques i.e. simple and complex coacervation techniques. Microcapsules were formed using core material (oil) & wall material (gum). Selection of core material (oil) was done by keeping in mind the aroma and therapeutic importance of various essential oils. Under the present study, two oils i.e., citronella oil and lemon grass oil were selected due to their easy availability, pleasant aroma, positive psychological effects on human beings etc. Combinations of gum and oil used under the present study are shown in the Table 1.

Wall materials (gum) were used to encapsulate the core material (oil). So the wall materials which were compatible with the core material and fabrics, were selected carefully. Two gums were selected as wall material from different type of natural gums i.e., gum acacia (arabic), and sodium alginate. Formation of microcapsules in the solutions made with both the techniques was ensured by using Nikon Eclipse E1000 microscope (figure no 1). The finish was applied on wool fabric with the help of padding mangle machine.

Table 1: Combination of gum & oils for preparation of microcapsules and their application on the test specimen

Microcapsules used (gum and oils)	Wool fabric	
	SCT	CCT
Gum acacia + citronella	P	P
Gum acacia + lemon grass	P	P
Sodium alginate + citronella	P	P
Sodium alginate + lemon grass	P	P

Total 4 combinations X 2 Techniques = 8 finished wool specimen

(SCT- simple coacervation technique, CCT complex coacervation technique)

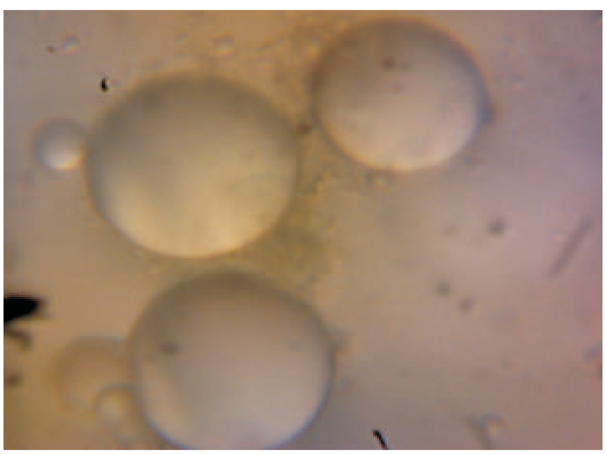

Fig. 1: Formation of microcapsules in solution

Ensuring the presence of microcapsules on the treated wool fabric

After application of microcapsules on the rambouillet fabric, finished fabric was analyzed under

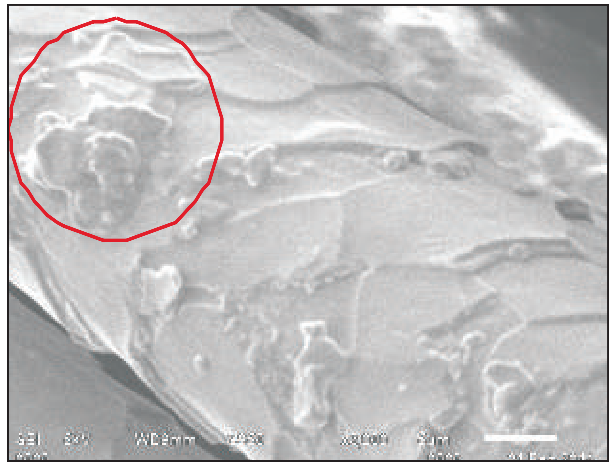

Fig. 2: Ensuring the presence of microcapsules

Scanning Electron Microscopy using JSM- 6610LV apparatus to ensure the presence of microcapsules on these test specimens. It was observed that microcapsules were visible on the fabric. Few images of micro-capsules are shown in figure no 2. Through SEM images each test specimen was also analyzed to check the shape, availability, quantity, size and uniformity of microcapsules.

Assessment of physical properties

Physical properties of both control and treated fabrics were evaluated to compare the difference that occurred due to application of finish (microcapsules), in order to ensure their suitability for the intended purpose. Before testing all the test fabric samples were kept in the standard conditions for 24 hours i.e. 210C temperature and 65 percent RH. It was done to avoid deviation in results due to hygroscopic nature of test fabrics. Tests were carried out to evaluate fabric count (ends and picks/inch^2), fabric weight (gm/m^2), fabric thickness (mm), bending length (cm), crease recovery angle (^{o}) and thermal conductivity (clo) of the prepared woven samples.

RESULTS AND DISCUSSION

Following physical properties of test specimen were enduated to compare the effect of microcapsulation finish on the test specimen.

Fabric count (ends x picks/inch^2)

It is evident from Table 2 that the fabric count of controlled rambouillet wool sample was noted as 43 x 41 whereas fabric count of treated samples with microcapsules (formed by simple coacervation technique) was observed as 42 x 40, 43 x 40, 42 x 41 and 43 x 41 ends x picks/inch. These microcapsules were made with gum acacia+ citronella oil; gum acacia + lemon grass oil; sodium alginate+ citronella oil and sodium alginate + lemon grass respectively.

In case of complex coacervation microencapsulation method rambouillet fabrics treated with gum acacia+ citronella oil and gum acacia + lemon grass oil, their fabric count was observed as 44 x 40 and 43 x 41 respectively. It is clear from table 2 that fabric count was found as 43 x 40 in the case of fabric treated with microcapsules of sodium alginate + citronella oil and 43 x 41 with sodium alginate + lemon grass. After comparing above results not much difference in fabric count of untreated and all the treated fabric samples of rambouillet wool was observed. Non-significant difference was found in fabric count of all specimens as compare to controlled samples after using simple and complex coaceravtion technique with all combinations of gum and oils.

Fabric weight (g/m^2)

It is clear from Table 2 that the weight of control sample of rambouillet wool was 150.5 g/m^2. It was found that maximum fabric weight was observed in rambouillet fabric finished with sodium alginate + citronella oil in both techniques simple coacervation (159.1 g/m^2) and complex coacervation technique (159.2 g/m^2). However minimum fabric weight was noted in case of gum acacia + citronella oil in both microencapsulation techniques i.e. 152.5 g/m^2 in simple coacervation technique and 152.8 g/m^2 complex coacervation technique.

Overall slight increase in weight was observed in treated rambouillet fabrics with fragrance finish prepared through Simple & complex coacervation techniques. Maximum fabric weight was found in microencapsulated fabric of sodium alginate + citronella (159.2 g/m^2) by using complex coacervation technique. The minimum weight of the microcapsulated fabric in gum acacia & citronella oil was found as 152.5 g/m^2 these microcapsules were prepared through simple coacervation technique. Non significant difference was found at 5 percent level of significance in weight of all fabrics as compared to controlled samples by using simple and complex coaceravtion technique with all combinations of gum and oils.

Fabric Thickness (mm)

Angappan and Gopalkrishnan (2002) reported that fabric thickness is related to some other fabric properties such as thermal insulation/ resilience, stiffness and abrasion etc. which are affected by fabric geometry.

It is evident from Table 2 that the thickness of rambouillet controlled fabric sample was observed as 0.52 mm. In case of microcapsules made with simple coacervation technique, maximum fabric thickness was observed as 0.57 mm, these fabrics were treated with microcapsules of sodium alginate + lemongrass oil. Minimum fabric thickness was observed in case of wool fabric treated with gum acacia+ citronella oil i.e. 0.53 mm.

In complex coacervation technique of microencapsulation, maximum thickness of Rambouillet sample was observed as 0.61mm when treated with microcapsules of sodium alginate + citronella oil and minimum thickness was observed in fabric treated withfinish of microcapsule made with gum acacia+ citronella oil (0.57 mm).

Table 2: Physical properties of controlled and finished Rambouillet fabric

Fabric	Microencapsulation technique	Combination of wall & core material	Fabric count (ends x picks/ inch)	Fabric Weight gm/ m^2	Fabric thickness (mm)	Bending length (cm)		Crease recovery (^{0})		Thermal conductivity (clo)
						Warp	Weft	Warp	Weft	
Rambouillet Wool fabric		Controlled	43×41	150.5	0.52	1.5	1.2	108.4	99.6	0.60
	Simple Coacervation	G + C	42×40	152.5	0.53	2.4	2.0	96	90	0.62
		G+ L	43×40	156.4	0.55	2.4	1.9	105.4	93.4	0.65
		S +C	42×41	159.1	0.56	2.1	2.0	107.4	98.6	0.63
		S +L	43×41	155.8	0.57	2.0	1.6	102	96.8	0.65
	Complex Coacervation	G + C	44×40	152.8	0.57	2.5	2.1	95	88.2	0.64
		G+ L	43×41	157.2	0.60	2.5	2.0	94.8	85.4	0.66
		S +C	43×40	159.2	0.61	2.0	1.8	93.4	85	0.64
		S +L	43×41	157.4	0.58	2.2	1.7	94	91.4	0.63

(G+C- Gum acacia + citronella; G+L- Gum acacia + lemon grass, S+C- Sodium alginate + citronella & S+L- Sodium alginate + lemon grass)

Overall maximum thickness of treated rambouillet fabric was noted with microcapsules of sodium alginate + citronella oil (0.61 mm) made by using complex coacervation technique where as minimum thickness was found with microcapsules of gum acacia+ citronella oil (0.53mm) prepared by using simple coacervation technique. Non significant difference was found at 5 percent level of significance in weight of all fabrics as compared to controlled samples by using simple and complex coacervation technique with all combinations of gum and oils.

Bending length (cm)

It is evident from Table no. 2 & fig. 3 that, bending length of controlled rambouillet wool sample was 1.5 & 1.2 in warp and weft directions respectively. It was observed that when rambouillet fabric was treated with microcapsulated finish of gum acacia and citronella oil, maximum bending length was found in simple coacervation technique i.e. 2.4 & 2.0 cm in warp and weft directions. Whereas minimum bending length was observed in case of sodium alginate + lemon grass oil microcapsules treated fabric i.e. 2.0 & 1.6 cm in warp & weft direction.

The maximum bending length of rambouillet fabric was observed when it was treated with microcapsulated finish formed with gum acacia + citronella oil made by complex coacervation technique (2.5 cm & 2.1cm in warp and weft direction) while minimum bending length was recorded with microcapsules of sodium alginate + citronella oil 2.0 & 1.8 cm in both warp and weft directions.

The results indicate that wool sample fabrics finished with microcapsules having gum acacia as wall material produced the greater stiffness then sodium alginate. This can be attributed due to the higher thickening property of gum acacia. Stiffer the fabric bending length is higher.

Aggarwal (2010) has also indicated that the fabric finished with microcapsules having gum acacia as wall material produced the most stiff fabrics followed by sodium alginate and the least, by gaur gum.

Crease Recovery (^{0})

It is evident from Table no. 2 that crease recovery angle of controlled fabric sample of rambouillet wool was observed as 108.40 in warp and 99.60 in weft direction. In simple coacervation technique maximum crease recovery was found in Rambouillet fabrics treated with microcapsules of sodium alginate + citronella oil i.e. 107.4^0 & 98.6^0 in warp and weft direction, while minimum crease recovery angle was found in gum acacia and citronella oil i.e.96^0 & 90^0 in warp and weft direction. In case of complex coacervation technique of microencapsulation the crease recovery angle of treated rambouillet samples were found as 95^0 & 88.20 , 94.8^0 & 85.4^0, 93.4^0 & 85^0 and 94^0 & 91.4^0 in both warp & weft directions when treated with microcapsules of gum acacia + citronella oil, gum acacia + lemongrass oil, sodium alginate + citronella oil and sodium alginate + lemongrass respectively.

Overall minimum crease recovery angle of finished rambouillet fabric was noticed when it was treated with microcapsules of gum acacia + citronella i.e. 96^0 & 90^0 by using simple coacervation technique. Further decrease in

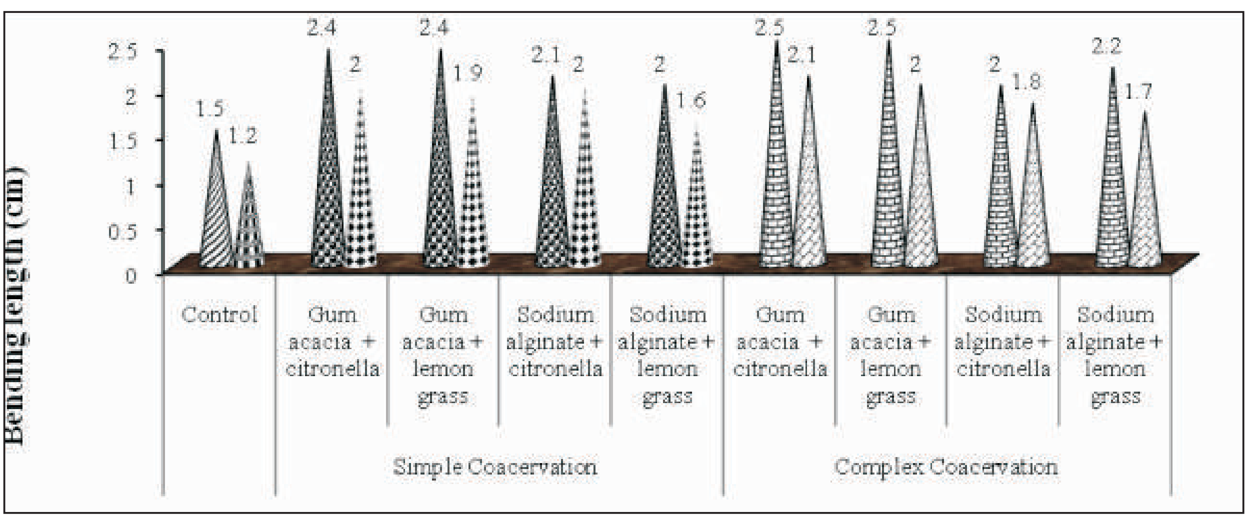

Fig. 3: Difference in bending length (cm) of control and microcapsulated rambouillet fabric

crease recovery was found in the fabric finished with sodium alginate + citronella oil 93.4 & 85^0 (warp and weft) by using complex coacervation technique. This may be because of higher viscosity of coating material in this case of fabric samples treated with microcapsules of complex coacervation technique causing the crease to be retained in the fabric for a longer duration and be more defined and prominent than crease in the fabric treated with microcapsules made with simple coacervation technique. Non-significant difference was found in crease recovery of all specimens as compare to controlled samples after using simple and complex coaceravtion technique with all combinations of gums and oils.

Results are in accordance with Sathiyanarayanan *et .al.* (2010) who has stated that the crease recovery angle decreases after microencapsulation finish. He said that the decrease in crease recovery angle may be due to stiffness in microencapsulated fabric as gum material makes a thin coating on the fabric surface.

Thermal conductivity (Clo)

It is evident from Table 2 that thermal conductivity of controlled rambouillet fabric was observed as 0.60 clo. Clo is the measure of thermal resistance it includes the insulation provided by any layer of trapped air between skin and clothing and insulation of clothing itself. The clo value considered as comfortable for summer & winter are 0.5 and 0.8 respectively. In case of rambouillet fabric finished by microcapsules made with simple coacervation technique with gum acacia + lemongrass and sodium alginate + lemongrass oil thermal conductivity was found same i.e. 0.65 clo. In case of complex coacervation technique of microencapsulation the thermal conductivity was recorded maximum for the Rambouillet fabric treated with microcapsules of gum acacia + lemon grass oil the clo value was observed as 0.66 clo.

Tortora (1978) opined that the wool provides good insulation. The low conductivity of wool fiber is due to its ability to trap air between the fibers and thus wool is a good choice for cold weather clothing. This property of rambouillet wool makes it an excellent choice for making apparels where warmth and softness are required with good aesthetic appeal. Non-significant difference was found in thermal conductivity of all specimens as compared to controlled samples after using simple and complex coacervation techniques of microencapsulation with all combinations of gum and oils.

Testing of wool Specimen to assess durability of finish

To test the durability of the finish various tests like rubbing fastness, wash fastness, fastness to sunlight and perspiration fastness were applied on the finished fabric samples. Then intensity of aroma increased or decreased was assessed. To calculate weighted mean score of all ratings, weights were assigned to the following properties on the basis of their functionality.

Table 3: Durability assessment of specimens finished with microcapsules formed by simple and complex coacervation techniques

Fabric	Microencapsulation technique	Combination of wall & core material	Rubbing fastness (cycles)						Washing fastness (washing cycle)			Light fastness	Perspiration fastness		Weighted mean score	Rank
			Dry			Wet							Acid	Alkaline		
			10	20	30	10	20	30	2	5	10					
Wool fabric	Simple coacervation technique	G + C	4	4	4	4	4	3	3	2	1	4	2	2	12.2	7
		G+ L	5	5	4	5	5	4	4	3	1	5	2	3	15.1	1
		S+C	4	4	4	4	4	4	4	3	1	4	3	2	13.3	4
		S+L	4	4	4	4	4	4	3	3	1	4	2	2	12.9	5
	Complex coacervation technique	G + C	4	4	3	5	4	3	3	2	1	4	2	2	12.2	7
		G+ L	5	4	4	5	4	2	5	4	3	5	2	2	14.6	2
		S+C	4	3	3	4	4	3	4	3	2	4	3	3	12.5	6
		S+L	5	4	4	4	3	2	5	4	3	5	2	2	13.8	3

(G+C- Gum acacia + citronella, G+L- Gum acacia + lemon grass, S+C- Sodium alginate + citronella & S+L- Sodium alginate + lemon grass)

- Rubbing fastness - 4
- Wash fastness - 3
- Light fastness - 2
- Perspiration fastness - 1

On the basis of weighted mean score, ranks were provided to all the combinations of oils and gums from highest to lowest.

It is evident from Table 3 that in case of simple and complex coacervation techniques of microencapsulation, the rambouillet fabric treated with microcapsules of gum acacia + citronella, gum acacia + lemon grass, sodium alginate + citronella oil and sodium alginate + lemongrass oil were observed and accordingly weighted mean score & ranks were assigned. It was found that best results of durability of fragrance in finished rambouillet fabric were derived from the fabrics microencapsulated with gum acacia + lemon grass oil by using simple and complex coacervation technique which was ranked as 1 and 2 respectively. It was followed by sodium alginate + lemon grass oil (rank 3) by using complex coacervation technique. Fabric treated with microcapsules of gum acacia + citronella oil in both simple and complex coacervation techniques were found less durable as compared to the gum acacia+ lemon grass.

CONCLUSION

It can be concluded from the present study that, the core and wall materials should have compatibility with each other, which will ensure the formation of microcapsules. Wool a protein fiber can be successfully finished with oils used for aromatherapy. Physical properties of treated fabrics were not altered significantly, so such kind of finish is may be recommended as the functionality of treated fabric was enhanced. The durability of microcapsulation was also found as optimum.

It was found that best results of durability of fragrance in Rambouillet fabric were obtained from the fabric microencapsulated with gum acacia + lemon grass oil by using simple coacervation technique followed by sodium alginate + lemon grass oil by using complex coacervation technique. In the fashion world, wool fabrics have secured an eminent place due to their properties. With the application of Aromatherapeutic finish the functionality and importance of treated wool fabrics will be enhanced immensely.

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