CHAPTER – 5

Conclusions

OVERVIEW:

The conclusions are drawn for the polymerization of pH-responsive polymer, microencapsulation, structure confirmation, thermal characteristics, optical properties, and performance analysis of the synthesized and applied microencapsulated polymer to the product used for feminine hygiene.

In recent time, commercial products for feminine hygiene with functional and specific properties are expensive, and due to the cost, they are not affordable for rural areas. Also, sanitary napkins with high absorptivity, antimicrobial properties, and scent-added napkins are available in the market. As the products came into contact with very delicate parts of the body, sensitive skin, the main factor pH must be maintained at the time of menstruation, which is not covered in the commercial napkins. And so the idea of generation of pH-responsive polymer, its microencapsulation, and application on the outermost layer of sanitary napkins struck, and the work had been initialized.

For the said purpose seven pH-responsive polymers were prepared and those are, poly(AA-co-ACN), poly(MMA-co-MAA), poly(AA-co-MMA), poly(MAA-co-ACR), poly(MMA-co-ACR), poly(AA-co-ACN) grafted with sodium acrylate, and poly(MAA-co-ACR-co-ACN). These prepared pH-responsive polymers were micro encapsulated n-eicosane, and then applied on the outermost layer and in also at the middle layer of the sanitary napkins, and the performance analysis of the napkins were compared with commercially available sanitary napkins.

In the work presented here, encapsulation of n-eicosane with the prepared pH-responsive polymers had been achieved successfully, which is denoted as pH-responsive microcapsules. Microcapsules contain PCM as the core and pH-responsive polymer as the shell. The emulsion of the microcapsules has been performed by in-situ polymerization technique. SEM and FTIR analysis support the formation of pH-responsive microcapsules by analyzing their chemical structure and compositions. The TGA curve supports the stability of all the prepared pH-responsive polymers, i.e., SAPs and mSAPS. So, the above polymer-coated napkin can be stored in a container for transportation, which consumes more time, and the coated polymers will not lose their stability.

The cotton-carded web coated with SAP-1C, 2C, 3D, 4B, 5B, 6C, and 7C, mSAP-1C, 2C, 3D, 4B, 5B, 6C, and 7C were tested for FSC and AUL, and the results were comparable with commercially available napkins. The FSC and AUL values for CAs are very lower compared to prepared napkins. And the data also suggest that the SAP-3D and mSAP-3D coated sanitary napkins show excellent value for FSC and AUL, and so it is the best suitable SAP and mSAP for both the tap water and the saline solution. Other SAP-coated sanitary napkins are approximately compatible with each other, while

mSAP-coated napkins had the higher FSC and AUL values than SAP-coated napkins. Also, in case of absorption capacity, SAP-3D and mSAP-3D coated sanitary napkins had shown the highest absorption capacity with 133.08 g/g for SAP and 126.40 g/g for mSAP coated napkins for 8 hours duration, which is the standard time to replace the napkins after tilization. Others SAP-coated napkins also suggested the absorption between 95.84 and 129.7 g/g for 8 hours, and mSAP-coated napkins show the absorption of 94.87 g/g as the lowest and 124.02 as the highest value.

The wet back property of the SAPs/mSAPs-coated sanitary napkins was studied to analyze the degree of moisture that is present in the sanitary napkin. The analysis suggests that all mSAPs-coated samples suggest better results compared to SAPs-coated as well as to commercially available CAs. SAP-1C, SAP-2C, and SAP-3D coated sanitary napkins are superior to the commercially available products in terms of wet-back qualities, but control is superior to them. SAP-4B and SAP-5B's wet back properties are slightly different, and they are displaying higher values than SAP/mSAP-1C, while when they are microencapsulated, they show the acceptable result for both 1st and 2nd wet. Because cotton absorbs water well and SAPs/mSAPs are water-loving, the top layer of needle-punched cotton in the samples shows that the wet back feature of the commercial product is similar.

The CAs seem to exhibit a faster rate of transportation. As a result, the amount of time necessary to move the fluid from the surface to the inner section is less than 2.58 seconds, which is denoted as strike-through property. The napkin coated with SAP-3D required fluid conveyance within 2.43 seconds, while the napkin coated with mSAP-3D required fluid conveyance within 2.41 seconds. While SAP/mSAP-6C shows the comparable result for strike-through property with the commercial one. Wicking heights of the commercially available napkins are poor compared to SAP/mSAP-coated napkins. Specifically for SAP/mSAP-3D, the wicking height is highest, and it rapidly increases from SAP/mSAP-1C, 2C, and then 3D. For other SAP/mSAP-coated sanitary napkins, the wicking height is lower, but still higher compared to commercial ones.

pH is the main factor of the study, as it is necessary to maintain during menstruation for better hygiene and to control other factors related to the body also, like itchiness, mood swings, and uneasiness. Generally, commercially available sanitary napkins have a pH near neutral. SAP-3D and mSAP-3D have the lowest pH values of

3.02 and 3.00, respectively, and they are most suitable for coating the sanitary napkins, as they will come into contact with menstrual fluid with a pH of 7.4, react with the fluid, and bring the pH value down, which the feminine vagina required, and that is acidic. Other SAPs and mSAP-coated napkins have an acidic pH, and they can also be used for the coating of sanitary napkins, which can be nominated as pH-responsive sanitary pads. The antimicrobial properties of SAPs/mSAPs-coated napkins are more favorable as compared to commercially available products. Also, the physical attributes of SAPs/mSAPs-coated napkins are promising as they show a negligible difference.

When these polymer-coated napkins will be utilized for the purpose for which they are manufactured, the major concern is about the skin contact, i.e., skin irritation. Different communities, people, areas, and societies have different skin characteristics, like normal skin and self-assessed sensitive skin. Numerous subjects had been selected for the same test, and 5-days, 4-days, and 21-days analysis for the skin irritation suggested that SAP/mSAP-3D coated sanitary napkins had the lowest values, which clearly indicated that those are not generating any skin irritation. Specifically, all the microencapsulated polymer-coated sanitary napkins show excellent values compared to SAP-coated and commercially available products.

The disposal of the sanitary napkins is also a burning question, and the liquid in which they are disposed, then the worry for the aquatic system must come into the picture. So, the liquid in which SAPs/mSAPs-coated sanitary napkins will be discharged has been studied. We measured the liquid's hardness, alkalinity, and chloride content before immersing the prepared napkins in it. SAP/mSAP-3D-coated napkins suggested lower hardness, alkalinity, and chloride content compared to other SAP/mSAP-coated napkins, also lower compared to commercial samples. Also, COD and BOD indicate that conventional samples had higher values compared to prepared ones. All the prepared samples were showing the results under the tolerance limits.

So, the performance analysis of all the SAPs/mSAPs coated sanitary napkins and comparison with the commercially available napkins concluded that:

- pH-responsive polymer and microencapsulation with the same have been achieved successfully.
- SAP/mSAP-6C coated sanitary napkins show the highest FSC and AUL values.

- Absorption capacity of SAP/mSAP-3D coated sanitary napkins suggests the highest absorption till 8 hours, a suitable time period for changing the napkin.
- SAP/mSAP-4B and 5B-coated napkins possessed satisfactory wet back, and SAP/mSAP-6C suggests the highest values for strike-through properties.
- Excellent wicking height had been achieved for sanitary napkins which are coated with SAP/mSAP-3D.
- SAP/mSAP-3D coated sanitary napkins show the lowest pH, and that is exactly required.
- For antimicrobial analysis, again SAP/mSAP-3D coated sanitary napkins are best suitable.
- Physical attributes of SAP/mSAPs-coated sanitary napkins, i.e., length, width, weight, and thickness, are comparable to the commercial product.
- SAP/mSAP-3D coated sanitary napkins support negligible or nil irritation.
- Effluent analysis also suggests the lowest load had been received in the case of SAP/mSAP-3D coated sanitary napkins.

Based on the obtained results, it is evident that SAP/mSAP-3D is the optimal choice for coating poly(AA-co-MMA) sanitary napkins.

To develop a feminine napkin that is both cost-effective and superior to current products, the most efficient approach is to integrate or utilize Super Absorbent Polymers (SAP) and microencapsulate the same. This will fulfil all the mentioned objectives, as there is a significant demand for such a product.