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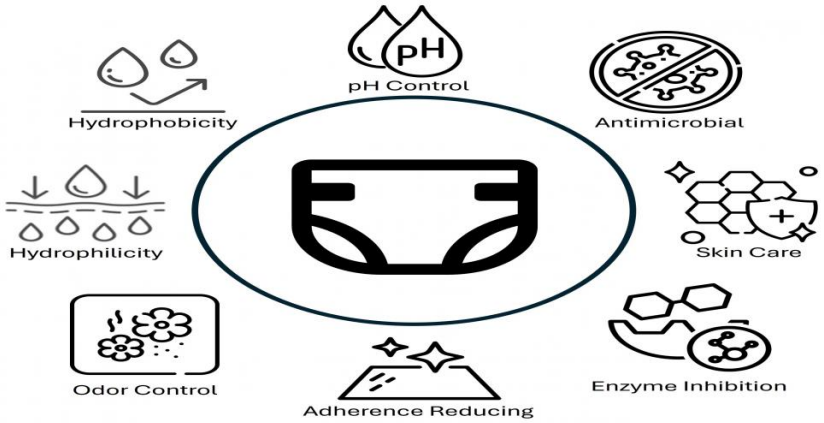
Nonwoven Surface Treatments for Diaper Rash Prevention

Mehmet Sinan Tübcil*
Ph.D. Student
Molecular Biology, Genetics and Bioengineering , Sabanci University , Turkey

Şebnem Kemaloğlu Doğan
Dr.
R&D Center , Hayat Kimya , Turkey

Bekir Dızman
Assoc. Prof.
Materials Science and Nano Engineering , Sabanci University , Turkey



To assess diaper rash prevention strategies and diaper preferences in Turkey, a Computer Assisted Web Interview (CAWI) was conducted with 306 mothers nursing infants aged 0 to 3 years. The top three factors they prioritized were the diaper top sheet quality, absorbency, and flexible side bands. The first two are specifically related to nonwoven top sheet treatments. Nonwoven top sheets of the diaper are made of Polypropylene (PP). Due to hydrophobic character of PP, they are treated with surfactants. There are other kind of treatments encompass a wide range of treatments aimed at achieving specific objectives such as imparting electrokinetic potential, dyeability, pH control, odor control, and antimicrobial activity. Understanding the types and effects of surface treatments is essential for optimizing the performance and functionality of diaper top sheets. We analyzed the products on the Turkish market, patents and articles on the literature.

Keywords: Nonwoven Surface Treatments, Diaper Rash, Diapering Routines, Hydrophilicity, Hydrophobicity, Surfactants

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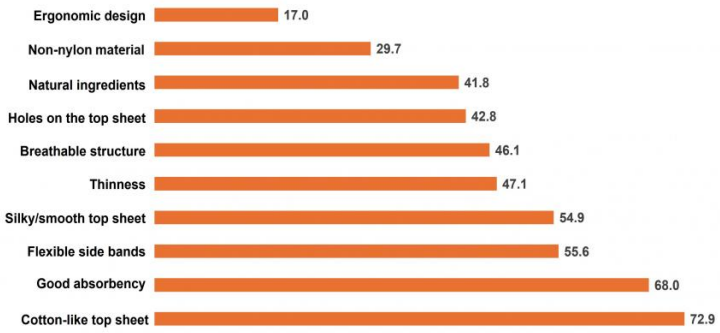
Figure 1. Features Customers Associate with Diaper Rash Prevention (%)



1.Introduction

Diaper rash mostly affects skin sites including the buttock, perianal, genital, and intertriginous areas . It is primarily associated with prolonged exposure to urine and feces. The prevalence of this condition varies across different populations and age groups, ranging from 50% to 65% . Notably, approximately 25% of babies experience diaper dermatitis during their first four weeks of life, with the highest incidence occurring between 9 and 12 months . While moderate to severe diaper rash appears to have been more prevalent in previous times, currently, due to modern disposable diapers with super absorbents, the condition is mostly mild . The etiology of diaper rash is a widely studied subject. According to the literature, the urease enzyme in the feces breaks down the urea in the urine and forms ammonia. This increases the pH of the skin and the environment in the

diaper. The increased pH increases the activity of lipase and protease enzymes that prefer an alkaline environment . These enzymes destroy the corneocyte proteins and interstitial lipid lamellae of the SC and increase the permeability of the skin, which has become fragile with moisture and friction . The increased permeability allows irritants in the feces, such as bile salts, to penetrate the lower layers of the skin . These substances trigger the immune system and the initial secretion of IL 1 alpha and TNF alpha initiates a subsequent series of pro inflammatory chemokines and cytokines, leading to skin inflammation and erythema . Prevention strategies play a crucial role in managing diaper rash. Protecting the skin barrier, minimizing harsh cleansing, maintaining skin surface dryness, and reducing direct contact with urine and feces are essential aspects of prevention. General recommendations for both treatment and prevention include frequent diaper changes, the utilization of innovative disposable diapers with super absorbent and aeration materials, gentle cleansing methods during diaper changes, and the application of barrier creams to minimize exposure to urine and feces . The key to ensuring compliance and adherence lies in educating parents and caregivers thoroughly about the causes of IDD, preventive measures , and developing new anti diaper rash nonwoven surface treatments for top sheets.

2.Materials and Methods

A survey was conducted by computer assisted web interviews (CAWI) method with 306 mothers, aged 28 to 45, residing in Istanbul and nursing their infants aged 0 to 3. The mothers independently decided on diaper brands and diapering practices and had moderate to high income (Socioeconomic groups A, B, C1, and C2). The study ensured a balanced representation of infant gender, mother experience, and diaper sizes. Interviews were conducted in the first quarter of 2023. Content analysis of the formulations used in the diapers in the Turkish market were performed. Various characterization methods (DSC, TGA, NMR, FTIR, etc.) have been used to determine the active ingredients, auxiliary components, and their ratios of the formulations.

3.Result and Discussion

Investigated diapers are hourglass shaped products consisting of 3 layers. The top sheet layer, which directly contacts the skin and is the subject of the surface modifications, is made of PP. Formulations that increase the absorbency of the PP top sheet layer and give it a soft feel and a pleasant scent are commonly used in the market. The second diaper layer is the absorbent layer containing super absorbents, such as sodium polyacrylate, that give the diaper its absorbency. The last and outermost layer of the diaper is the polyethylene (PE) layer which prevents odor and liquid leakage. The odor free diaper brands are also preferred. To achieve this objective, diaper brands incorporate a breathable film, comprising PE, which facilitates breathability. Furthermore, their back sheets are constructed from NW PP. This design simultaneously restrains the escape of odors from the diaper while affording a continuous influx of fresh air to the skin . Nearly half of the mothers mentioned breathability specifically in our survey (Figure 1). Some brands also use perfumes in their diapers to mask the odor, but perfume free brands are recommended by experts because of the detrimental health effects of fragrances including contact dermatitis (irritant and/or allergic), and non eczematous contact reactions . Formulation of one of the most selling brands is characterized as emulsion of cationic antistatic agents and cationic siloxanes with stability of 12 hours. Its active content is 17%. Its pH is measured as 5 and the contact angle of distilled water on treated PP nonwoven is approximately 115o and 70o on PP film. Another formulation is characterized as emulsion of hydrophilizing and wetting agents with stability of 24 hours. Its active content is 94%. Its pH is measured as 7 and the contact angle of distilled water on treated PP nonwoven is approximately 110o and 70o on PP film. The characteristics of these formulations indicate that developing novel nonwoven surface treatments for diapers is achievable by simplifying formulations through the use of

multifunctional polymers. While small molecules remain prominent, polymer based formulations offer greater versatility. Simplifying these formulations could facilitate easier adjustments to introduce new features. This approach may also enable their application in other disposable hygiene products, such as wet wipes and feminine hygiene items. To ensure safety, these polymers should be biocompatible, biodegradable, and produced via sustainable synthesis methods. Smart materials, nanofibers, and nanoparticles are gaining prominence in this field, as concerns about sustainability, biodegradability, biocompatibility, product safety, and compliance with environmental regulations grow. Addressing these concerns will be key to driving the development of next generation disposable hygiene products that align with evolving regulations and consumer expectations.

4.Conclusion

In this study, we examined various nonwoven surface treatments and their effectiveness in preventing diaper rash. The findings underscore the importance of top sheet quality and absorbency, factors identified both in literature and by mothers in Turkey, as key contributors to rash prevention. Surface treatments aimed at enhancing the hydrophilicity, softness, and breathability of nonwoven materials are critical in improving diaper performance and skin health. The use of formulations with surfactants, hydrophilizing agents, and cationic additives demonstrates the innovative approaches taken by diaper manufacturers to address diaper rash. By optimizing these treatments, manufacturers can better meet the needs of consumers while minimizing irritation risks. Future research should continue exploring advanced surface modifications and their long term effects on skin health, aiming to improve both the comfort and functionality of disposable diapers. Acknowledgements This work was supported by the Scientific and Technological Research Council of Turkey (TUBITAK) with project codes 5220091 and 118C047 and Hayat Kimya Sanayi A.Ş.

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