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Beauty and Cleanliness Yuxiu - Research on Beauty Products Based on Cutting edge Low Carbon Technology Background

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ABSTRACT
With the continuous advancement of science and technology in the new era, the green concept of sustainable development has become a consensus in the international community. Consequently, industries and enterprises worldwide are prioritizing global sustainable development as their top strategic goal. As technology remains the primary driver of productivity growth, low-carbon technologies have emerged as a defining trend for both industries and businesses. The cosmetics market, still a "promising sector" with vast untapped potential, continues to evolve across R&D, production, and packaging. This study employs literature review and case analysis methodologies to conduct an in-depth exploration of innovative low-carbon technologies in cosmetic product development, production, and packaging processes.

KEYWORDS
Low carbon technology; Beauty products; Sustainable development; Environmental protection

1 Introduction

The intensifying global warming and environmental pollution have prompted governments and businesses worldwide to prioritize low-carbon economic development. As a vital sector of the consumer goods market, the cosmetics industry faces urgent challenges in addressing carbon emissions throughout its production and consumption processes. This paper explores the application of cutting-edge low-carbon technologies in cosmetic products, aiming to provide theoretical and practical support for the sustainable development of the beauty industry.

2 Overview of Low-carbon Technologies

Low-carbon technology refers to a technological system that reduces greenhouse gas emissions and enhances resource efficiency through innovation. Its core objective is to decouple economic growth from carbon emissions, promote the development of a low-carbon economy, and address global environmental challenges. Consequently, the application of low-carbon technologies will become a defining trend in future development.

3 Application of Low-carbon Technology in Beauty Products

3.1 Raw Material Selection

The selection of raw materials in cosmetics is a critical factor influencing their carbon footprint. Traditional beauty products commonly use synthetic chemicals and non-degradable materials, which impose significant environmental burdens by consuming vast amounts of energy while generating substantial waste. Therefore, exploring more eco-friendly materials has become a crucial pathway for the cosmetics industry to reduce carbon emissions.

First, using renewable raw materials is one of the most effective ways to reduce environmental impact. Plant-based ingredients like coconut oil, aloe vera extract, and tea tree oil are not only abundant and sustainably cultivated, but also typically require less energy during production. Moreover, these natural components can be easily broken down by the environment after use, minimizing long-term effects on ecosystems.

Secondly, the application of green chemicals represents another crucial aspect in reducing the carbon footprint of cosmetics. Green chemicals refer to those designed to minimize harmful substances during their design, manufacturing, and usage phases. For instance, adopting non-toxic solvents and catalysts not only helps reduce energy consumption and pollution in production processes but also ensures product safety for consumers. By optimizing chemical reaction conditions and minimizing byproduct formation, cosmetic manufacturing becomes more efficient and environmentally friendly.

In addition, choosing locally produced raw materials can effectively reduce carbon emissions caused by long-distance transportation. By establishing local supply chains, companies can shorten transportation distances and reduce energy consumption and greenhouse gas emissions during the logistics process.

3.2 Production Process Optimization

By introducing green manufacturing technologies, the cosmetics industry can significantly reduce carbon emissions and promote sustainable development in production processes. These green technologies include low-energy equipment, smart manufacturing systems, and waste recycling techniques that not only enhance production efficiency but also minimize environmental impact.

The adoption of energy-efficient equipment stands as a cornerstone strategy for reducing carbon emissions in cosmetic manufacturing. Unlike conventional production systems that typically consume substantial amounts of energy, these modern solutions feature optimized designs and cutting-edge technologies that significantly lower power consumption. Key implementations like high-efficiency motors, energy-saving lighting systems, and heat recovery units enable reduced electricity usage and fuel consumption without compromising production efficiency, thereby effectively cutting down on CO2 emissions.

Secondly, the implementation of smart manufacturing systems has revolutionized the production of beauty products. By leveraging IoT, big data, and AI technologies, these systems enable real-time monitoring and optimization of production processes, achieving precise resource allocation and energy minimization. For instance, smart sensors track equipment performance to promptly identify and resolve energy consumption issues; big data analytics refine production schedules to reduce unnecessary energy waste; AI algorithms predict maintenance needs, preventing energy loss and production disruptions caused by equipment failures. Through these innovations, smart manufacturing systems not only boost production efficiency but also significantly lower carbon emissions.

Meanwhile, waste recycling technology serves as a vital component of green manufacturing in the cosmetics industry. Production processes generate various waste streams—including wastewater, exhaust gases, and solid residues—which pose significant environmental risks if left untreated. By implementing advanced recycling solutions, these materials can be effectively processed and repurposed. For example, wastewater treatment technologies purify production effluents for reuse, reducing water consumption and wastewater discharge. Exhaust gas treatment systems filter and adsorb harmful emissions, converting them into harmless substances to minimize air pollution. Solid waste recycling technologies classify and process industrial byproducts into new raw materials or energy sources, thereby alleviating the environmental burden caused by landfilling and incineration.

The adoption of cold processing technology as an alternative to traditional high-temperature methods stands as a prime example of energy conservation and carbon reduction in the cosmetics industry. Conventional high-temperature processing requires substantial energy to heat raw materials while generating significant carbon dioxide emissions. In contrast, cold processing employs mechanical forces, ultrasonic waves, or low-temperature chemical reactions, eliminating the need for high-temperature conditions. This approach not only drastically reduces energy consumption and CO2 emissions but also preserves the bioactive components of raw materials. By maintaining these active ingredients, the technology enhances product quality and efficacy, ultimately boosting market competitiveness.

3.3 Packaging Design Innovation

The choice and design of packaging materials have a significant impact on the carbon footprint of beauty products. By adopting biodegradable, recyclable packaging materials such as paper packaging, bioplastics, and reusable containers, we can significantly reduce environmental pollution caused by packaging waste and thereby lower carbon emissions.

First, selecting appropriate packaging materials is crucial for achieving low-carbon packaging design. Paper packaging, with its renewable and biodegradable properties, has gradually become a preferred choice for the beauty industry's low-carbon packaging. Paper packaging produced from sustainably managed forest resources not only reduces dependence on petroleum-based plastics but also mitigates long-term environmental impacts through biodegradation. Moreover, bio-plastics as an emerging material, derived from renewable resources like corn starch or sugarcane, help address the environmental accumulation and pollution issues caused by traditional plastics through their biodegradable process.

Reusable containers are a vital component of low-carbon packaging design. These containers can be washed and reused after use, reducing the demand for disposable packaging and consequently lowering overall packaging waste. For example, MAC's "Back-to-MAC" program encourages consumers to return used product packaging to stores for recycling. As a reward, customers receive a free lipstick. This recycling initiative not only minimizes waste generation but also promotes eco-friendly consumption habits.

Secondly, optimizing packaging design to reduce excessive packaging is a crucial measure for lowering carbon emissions. Over-packaging not only wastes resources but also increases energy consumption during transportation and storage. By adopting rational design approaches that minimize unnecessary packaging layers and bulk, material usage and transportation energy consumption can be effectively reduced. For instance, implementing simple and compact packaging designs can decrease material consumption while lowering the carbon footprint of products during transit. Furthermore, modular packaging solutions enable compatibility between components for different products, simplifying

production and inventory management processes while enhancing logistics efficiency.

Furthermore, innovative packaging designs can integrate smart technologies to achieve additional eco-friendly features. For instance, embedding traceable RFID tags on packaging enables brands and consumers to track product lifecycles and monitor material recycling progress. Through this intelligent management system, brands can optimize supply chains and further reduce carbon emissions.

4 Case Analysis

Select several typical beauty brands and analyze their successful experience and practice in the application of low-carbon technology.

4.1 Low-carbon Innovation in Raw Material Link

In adopting natural ingredients and sustainable materials, Yixian Group has implemented reforms in its Sustainable Procurement Policy to promote plant-based materials like natural coconut oil and oat extracts, while encouraging supply chain partners to use sustainable palm oil. As of 2023, 65 of its suppliers have obtained certifications including ISO9001 (Quality Management System), ISO45001 (Occupational Health and Safety Management System), and SA8000 (Social Accountability International) certifications, ensuring low-carbon sourcing and traceability. Meanwhile, Natura Tonic Group, guided by its "2030 Sustainable Development Strategy", prioritizes FSC-certified paper for packaging in its infant care brand "Ji Chu" series. This initiative reduces excessive resource consumption while developing replaceable core designs to minimize material usage from the source.

In the development and application of bio-based materials, Shuiyang Co., Ltd. has established an industrialized synthetic biology system encompassing engineered microbial strains, pilot-scale conversion platforms, and proprietary manufacturing facilities. This innovation accelerates the advancement of biodegradable materials, such as using biodegradable polymers to replace conventional plastics and reduce environmental pollution from packaging waste. These materials not only match the performance of traditional plastics but also decompose rapidly in natural environments, effectively minimizing carbon footprints.

4.2 Low-carbon Transformation of Production Link

In the innovative practices of clean energy and intelligent manufacturing, Yixian Group's core manufacturing base, Yixian Biotechnology (Guangzhou) Factory, initiated its green transformation in 2024. Through a distributed photovoltaic power generation project with an installed capacity of 2324.34kWp, it achieved clean energy substitution, generating 2.0525 million kWh of electricity annually (equivalent to reducing 1, 785.68 tons of CO2 emissions). The factory also introduced an intelligent energy management system (EMS) for real-time energy consumption control, saving 146, 000 kWh of electricity in 2024. Its 2024 ESG report revealed a 61.7% year-on-year reduction in total carbon emissions across the entire value chain. Meanwhile, Nature Hall Group focused on production process innovation. Its flagship product, the Ice Skin Water bottle, adopted the world's first one-step molding gradient blowing technology, replacing traditional paint spraying to achieve zero paint consumption and reducing carbon emissions by over 90% compared to conventional methods. This technology has been in use for 16 years, supporting the production of over 110 million bottles. Additionally, the group implemented low-temperature cold-mixing processes, constructed concentrated water recycling systems, installed solar photovoltaic power generation equipment, and redesigned packaging for air cushion cream to further reduce carbon emissions.

4.3 Low-carbon Design of Packaging

Procter & Gamble (P&G) has launched Pantene Deep Water Bubble Hair Mask, which replaces traditional plastic with a paper-molded inner liner made from wood waste, recycled paper, and sugarcane bagasse. This innovation reduces plastic usage by 102 tons annually. The packaging also won the Mars Cup Packaging Innovation and Sustainability Award. Additionally, P&G's globally first Versafill Memory Foam Paper Packaging reduces storage and transportation volume by 85% through material and structural innovations, achieving both low-carbon packaging and improved logistics efficiency.

Perfect Diary, a brand under Eslite Group, features customized eco-friendly refill bags for its makeup remover, cutting plastic usage by 86%. The Micellar Essence Foundation reduces plastic by 91.6% through its replaceable packaging. All brand packaging meets FSC certification, with materials sourced from sustainable forest management systems.

Shiseido drives packaging recycling through refillable bottles, jelly core packaging, and a bottle return program. Their co-developed Liquiform® refillable technology reduces plastic use by 70% and cuts carbon emissions by 70% compared

to traditional packaging, while using a single material to enhance recyclability. The company's Red Yan Skin Revitalization Essence offers refill services for empty bottles, encouraging consumers to participate in resource regeneration.

Singaporean brand BHUMAN specializes in waterless skin care. Its enzyme cleanser powder is packaged in a bamboo bottle and an aluminum refill, combining classical design language with eco-friendly and high-end texture. The repeat purchase rate reached 33%.

5 Challenges and Responses

While low-carbon technology shows vast potential in cosmetics, several challenges remain. First, technical bottlenecks and insufficient R&D investment persist. For instance, eco-friendly materials like bagasse packaging (sugarcane waste) and bamboo fibers require high development costs, limiting their widespread adoption across products. Second, policy implementation and market mechanisms remain underdeveloped. Despite increased policy support, significant regional variations exist. Some areas prioritize short-term economic growth over environmental protection, undermining the effectiveness of energy-saving policies. Moreover, inconsistent low-carbon standards and complex certification systems increase compliance costs for small and medium-sized enterprises. Third, consumer awareness remains limited, with price-driven products still preferred. To address these challenges, the following recommendations are proposed: First, governments should enhance innovation support for raw materials and production technologies by establishing dedicated R&D funds and promoting industry-academia collaboration. This would encourage universities, research institutions, and companies to jointly establish laboratories for accelerated technology transfer. Second, improve policy frameworks and enforcement mechanisms by standardizing carbon emission accounting for the industry at local government levels, strengthening regulatory assessments, and continuously adjusting policies according to macroeconomic conditions. Third, promote consumer education and market guidance through social media campaigns disseminating environmental knowledge and innovative incentive programs to boost public engagement.

6 Conclusions

The integration of low-carbon technologies in cosmetics not only reduces environmental impact but also enhances brand image while addressing consumers' demand for eco-friendly products. To achieve low-carbon transformation, the beauty industry must overcome multiple barriers including technological challenges, supply chain constraints, policy implementation, and market dynamics. By driving innovation, providing targeted policy support, and guiding consumer behavior, we can establish a comprehensive green ecosystem spanning the entire lifecycle from R&D to production, consumption, and recycling. Future research should focus on standardizing carbon footprint measurement, exploring cross-industry technology transfer, and applying digital tools in low-carbon management. These efforts will create a win-win scenario for environmental benefits and commercial value, ultimately advancing sustainable development.

References

[1] Liu Li. Zheng Chunying, Chairman of Natural Hall Group: ESG Initiates a New Chapter for the Cosmetics Industry [J]. China Cosmetics, 2024, (04):48-50.

[2] Zhang Ruijuan. Research on Packaging Materials Based on Sustainable Development Theory [J]. Green Packaging, 2025,(02):31-34.

[3] Hu Hao. Research on Industry-Academia-Research Integration under the Trend of Green Packaging [J]. Shanghai Packaging, 2025,(01):242-244.

[4] Sun Xiaoxiao. "Plastic Reduction" Initiates a New Model for Green Cosmetics Ecology [J]. China Cosmetics, 2022, (04):50-51.

[5] Su Yueyi. Innovation-driven development, high-quality leadership for the future —— The 2024 Frontier Academic Conference on Cosmetics R&D and Quality Safety and the Second China Pharmaceutical University Translational Medicine Forum was successfully held [J]. China Cosmetics, 2025, (01):14-19.

[6] Su Yueyi. Piao Zhixian, China's Sustainable Development Officer at L' Oréal: Insights into the Green Future of Beauty [J]. China Cosmetics, 2024, (05):102-105.

[7] Beihao Group: Building an innovation ecosystem across the entire industry chain to help China's beauty technology strength go global [J]. China cosmetics, 2025,(05):40-41.

[8] Runhui Biotech: Reshaping Beauty Ingredients with Synthetic Biology, Competing for the INPD International Innovation Award [J]. China Cosmetics, 2025,(05):36-37.

[9] L'Oréal Group launches its first paper tube packaging[J]. Green packaging, 2019,(11):37.