A Study on the Emission Characteristics of Atmospheric Plasma Processes

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대기압 플라즈마 공정의 배출가스 특성에 대한 연구

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Abstract
Growing environmental regulations in textile manufacturing highlight the need for sustainable pretreatment technologies. This study investigates atmospheric plasma treatment as an eco-friendly alternative by analyzing by-product gas emissions and plasma uniformity in a mass-production system. The findings provide insights into process optimization for improved applicability in textile pretreatment.

1. Introduction

The textile manufacturing process requires large amounts of water, energy, and chemicals, and international regulations regarding their use are becoming increasingly stringent. Along with this, buyers' demands for improvement and consumers' growing awareness of ethical consumption are driving continuous interest in eco-friendly manufacturing facilities and related technologies. In order to reduce the substantial wastewater generated during dyeing, water-free dyeing technologies such as digital textile printing and supercritical fluid dyeing have been studied. However, the pretreatment processes (scouring and bleaching), which are the largest sources of wastewater, have often been overlooked, with efforts mainly focused on developing new chemicals and surfactants. Atmospheric plasma treatment for textile pretreatment utilizes oxygen in the air to decompose and gasify oils and sizing agents, thereby removing impurities such as finishing agents and lubricants from the fiber surface. At the same time, it enables surface modification to enhance dyeing efficiency. While this technique is known to offer diverse effects, its application in large-scale textile processing remains limited. Therefore, in this study, we analyzed the by-product gases generated during the operation of a mass-production plasma device and investigated the effects of plasma uniformity in order to optimize plasma processing conditions.

2. Experimental

2.1 Analysis of by-product gases from a mass-production plasma device

The generation characteristics of active species such as ozone and nitrogen oxides (NOx) were analyzed during plasma generation using air as the process gas.

2.2 Plasma uniformity analysis of a mass-production plasma device

To evaluate plasma stability and uniformity, discharge currents flowing through the electrodes were measured under identical flow-rate conditions during device operation.