The Controlled Production of Graphene Using Automated Mechanical Exfoliation

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Graphene, the monolayer form of graphite, is an atomically-thin material with unique physical and electrical properties, and a wide range of applications from stronger composite materials to transparent, flexible electronics. Much of current research focuses on discovering graphene's novel properties; this is most effective in pristine samples, necessitating the consistent production of high-quality graphene. Manual mechanical exfoliation, using Scotch tape to peel layers from graphite to produce monolayers, has traditionally been used to produce the highest-quality graphene of any other method. However, it produces low yields of small-sized flakes, and the presence of human variability prevents controlled, consistent graphene production. In this study, a novel motorized 3-roller device was used to automate exfoliation in order to achieve controlled graphene production. The roller method had two steps: exfoliation, where all three rollers were wrapped in adhesive tape in order to cleave graphite; and transfer, where the middle roller was replaced by another roller with holders for SiO2 substrates. The roller was used to control and determine the effects of five variables. Through this controlled study, it was determined that a combination of highly oriented pyrolytic graphite, Nitto brand tape, 120s O2 plasma treatment, moderate inter-roller pressure, and higher temperature produced significantly greater quantities of larger graphene flakes ($p<.05$, $p<.01$, $p<.001$). In the future, design changes should be made to the roller to optimize graphene production, and the device should be used to exfoliate other atomically-thin materials with different properties and applications, such as the semiconducting WS2 and the insulating hBN.

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