Nanodiamond Drug Device Could Transform Cancer Treatment

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A team of investigators at Northwestern University has developed a promising nanomaterial-based biomedical device that could be used to deliver chemotherapy drugs locally to sites where cancerous tumors have been surgically removed. The flexible microfilm device, which resembles a piece of plastic wrap and can be customized easily into different shapes, has the potential to transform conventional treatment strategies and reduce patients' unnecessary exposure to toxic drugs. The device takes advantage of nanodiamonds, an emergent technology, for sustained drug release.

The researchers, led by Dean Ho, Ph.D., demonstrated that the device releases the chemotherapy agent doxorubicin in a sustained and consistent manner, a requirement of any implanted device for localized chemotherapy. The results of the study appear in the journal *ACS Nano.*

"The thin device, a sort of blanket or patch, could be used to treat a localized region where residual cancer cells might remain after a tumor is removed," said Dr Ho. If a surgical oncologist, for example, was removing a tumor from the breast or brain, the device could be implanted in the affected area as part of the same surgery. This approach, which confines drug release to a specific location, could mitigate side effects and complications from other chemotherapy treatments.

In their study, Dr. Ho and his colleagues embedded millions of tiny drug-carrying nanodiamonds in the Federal Drug Administration

(FDA)-approved polymer parylene. Currently used as a coating for implants, the biostable parylene is a flexible and versatile material resembling plastic wrap. A substantial amount of drug can be loaded onto clusters of nanodiamonds, which have a high surface area.

To test the device's drug release performance, the researchers loaded the nanodiamonds with doxorubicin, a chemotherapeutic used to treat many types of cancer. They found the drug slowly and consistently was released from the embedded nanodiamond clusters for 1 month, with additional doxorubicin still remaining on the nanodiamonds at that time. The researchers note that these results suggest that a more prolonged release lasting several months or longer is possible. The device also avoided the "burst" or massive initial release of the drug, a common disadvantage with conventional therapy.

In control experiments, where the drug was present but without the nanodiamonds, virtually all of the drug was released within 1 day. By adding the drug-laden nanodiamonds to the device, drug release was instantly lengthened to the months-long timescale.

In addition to their large surface area, nanodiamonds have many other advantages that can be utilized in drug delivery. They can be functionalized with nearly any type of therapeutic. They can be suspended easily in water, which is important for biomedical applications. The nanodiamonds, each being 4 to 6 nanometers in diameter, are minimally invasive to cells, are biocompatible, and do not cause inflammation. In addition, nanodiamonds are relatively simple to make in large quantities.

To build the biomedical device, the researchers developed a streamlined approach whereby a double layer of parylene was fabricated, with the nanodiamond-drug complexes sandwiched in between. The bottom layer, approximately 20 to 30 microns thick, serves as the backbone of the

device, allowing it to be easily handled. For the top layer, the research team created a thinner semiporous film that allows the drug to slowly release from the device. “One of the most significant aspects of this work is that the fabrication procedures are highly scalable, meaning that hundreds, or even thousands, of devices potentially could be manufactured in parallel and at low cost,” said Dr. Ho.

This work is detailed in the paper “Nanodiamond-Embedded Microfilm Devices for Localized Chemotherapeutic Elution.” An investigator from Shinshu University in Nagano, Japan, also participated in this study. An abstract of this paper is available at the journal’s Web site.

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