The Case for Micro-fluidic Devices:
Safer Drug-Delivery for Patients

Every medical condition presents its own set of challenges. What is the best medication (or combination of medications) for restoring a patient's health? Once that question is answered, researchers grapple with the question of how best to administer those medications. The research of Dr. Ramana Pidaparti and his group, including VCU faculty and graduate students as well as faculty and students at the Indian Institute of Technology (IIT) in Kharagpur, addresses this need.

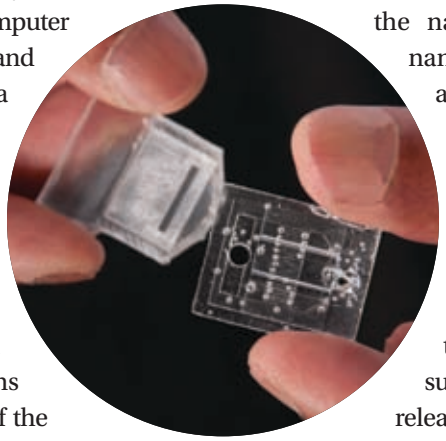
Pidaparti's team works with micro-fluidic devices to create safe, effective systems for drug delivery. These devices, due to their size and efficiency, are increasingly being used for various health care applications including treatment of ocular and respiratory diseases.

For patients with neovascular (or "wet") age-related macular degenerative disease, there is an urgent need for an implantable drug delivery device. An estimated 1.6 million adults in the US over the age of 50 suffer from age-related macular degeneration. This form of macular degeneration results from the growth of abnormal leaky blood vessels from the choroid and choriocapillaris beneath the macula. About 200,000 cases are diagnosed annually.

Only a few drugs are currently used to treat neovascular AMD since there is no device available to deliver the drug into the vitreous body of the eye. Drugs such as pegatanib sodium and ranibizumab (still in clinical trials) and bevacuzumab (off-label use in neovascular AMD) are delivered via repeated intravitreal injections of the drug into the eye. Yet the risks associated with repeated intravitreal injections are high: intraocular infections (endophthalmitis), intraocular hemorrhage, and retinal detachment.

Pidaparti and his team are working on an implantable, micro-fluidic device that will help to reduce the frequency of dosing and improve the pharmacokinetics of the drug in the eye.

In a project funded by the National Science Foundation (ECCS-1058067) and supported by the School of Engineering, Pidaparti along with Dr. Moorthy, President and CEO of Associated Vitreoretinal and Uveitis Consultants and Chairman of the Department of Ophthalmology at St. Vincent Hospital and Health Services in Indianapolis, Dr. Gary Atkinson, Associate Professor in Electrical and Computer Engineering, post-doc Dr. Guoguang Su and graduate students Jae-Hwan Lee and Kareka Aradi are developing an implantable drug delivery micro-device based on the fabrication of nano-channels and aided by computational studies for applications in treating ocular diseases such as AMD, diabetic retinopathy, uveitis, and glaucoma.



The drug delivery rate will depend on the nano-channel design specifications to meet the required flow rate at the exit of the device. Initially, the drug delivery device is being envisioned for application to treat macular degenerative disease with zero-order kinetics and continuous release rate over an extended period of time.

Schematics of the nano-drug delivery prototype structure are shown below. The drug to be delivered is contained inside a hydrogel, where it diffuses through a series of nanochannels and finally reaches the outlet, where it diffuses into the vitreous cavity at controlled rates. The use of hydrogels (MAI or MIRAgel consisting of Poly (methyl acrylate-Co-2-Hydroxyethyl acrylyte) will be explored as a means to actively induce the drug delivery into the nanochannels. The drug-laden hydrogel, nanochannels and outlet are contained within a top and bottom cover, which integrates all of the components together.

Currently, the device design concept is being investigated through computational simulations and prototyping. If the fabricated micro-device can satisfy the required drug release kinetics of the proposed nano-channel array and is suitable for the targeted application (ocular release device), a prototype drug delivery system will be developed and demonstrated during the next phase of the research program in collaboration with clinicians in implementing the developed device.

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