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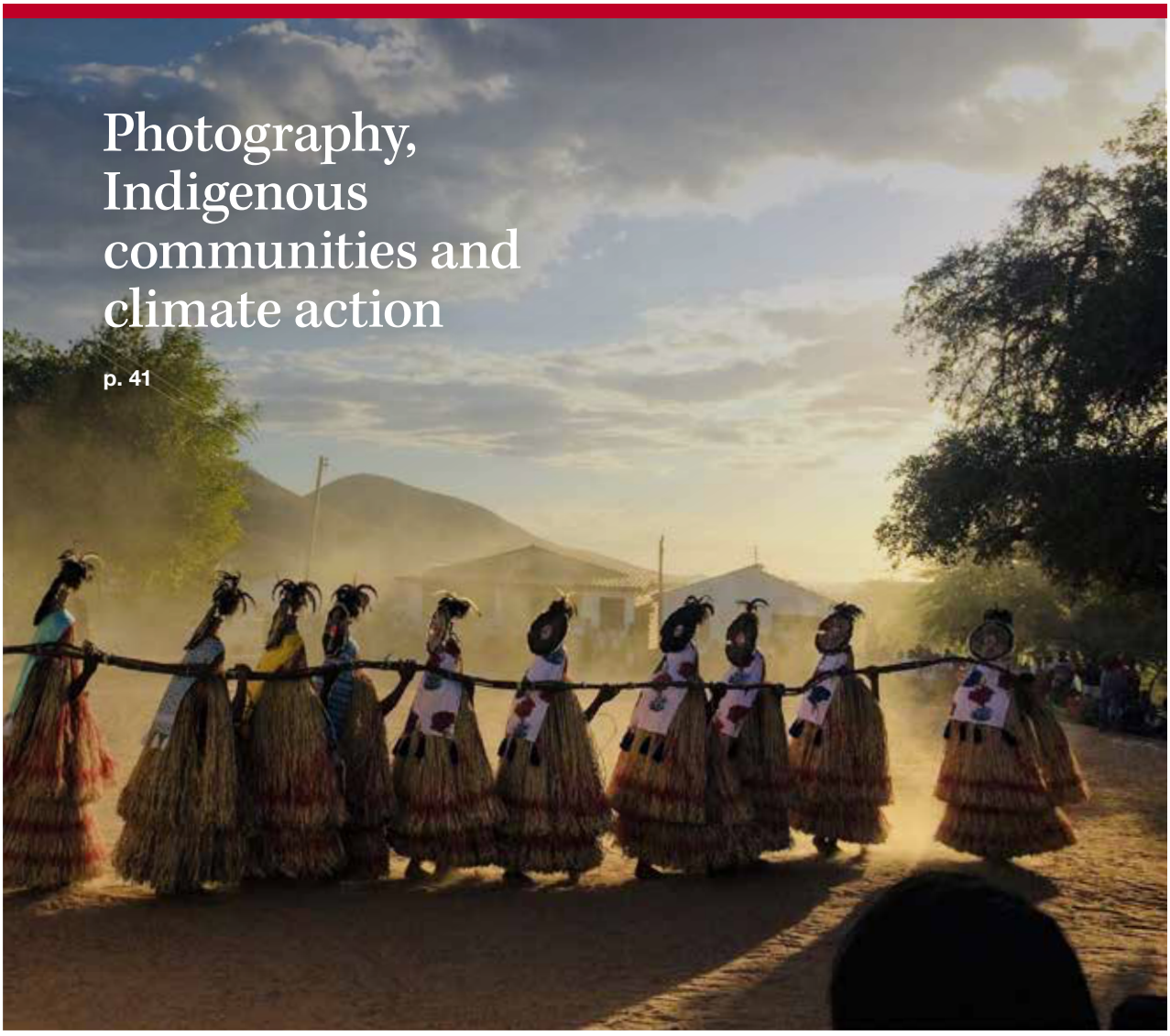

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Barnacle-inspired glue helps stem rapid blood loss

By **Karie Bate**, freelance writer

For the past decade, MIT research scientist and engineer Hyunwoo Yuk has been working to prevent 2 million people from dying every year due to rapid blood loss from serious injuries and invasive surgeries. How? He's passionate about solving difficult challenges. He is personally motivated. He likes to bake and to bake up new ideas. And he thinks outside the box.

"Engineers are folks who love to solve problems based on scientific tools and knowledge," he says. "I am always motivated when I learn about an important problem that has not been well solved and falls near the area of my expertise – even more so if it resonates personally."

When he was 22 years old, Hyunwoo Yuk's younger brother fell from five floors and suffered traumatic injuries, including severe hemorrhage from aortic damage. He later found out that the multiple operations his brother underwent took twice as long as planned due to challenges in controlling bleeding. "Having a strong personal motivation [to solve] the problem helped me get inspired and search for better solutions," he says.

His passion for home baking also sparks his creations. "I particularly enjoy making muffins. They're easy to make and it's fun to add different ingredients to them. They probably reflect my taste as a material scientist/engineer, as I like to make materials with relatively simple components but better performance."

OUT OF THE BOX APPROACH TO TACKLING RAPID BLOOD LOSS

Over the last seven years of his postgraduate studies, Hyunwoo Yuk has been baking a portfolio of bio-adhesive technologies to rapidly stop and control bleeding in people suffering from traumatic injuries or undergoing intensive surgeries.

The latest of his inventions, developed over the past four years, is a white toothpaste-like glue or paste that can adhere to surfaces covered with blood. And it's out of the box. He got inspiration from none other than the humble barnacle – a tiny crustacean that clings to rocks – to drive his innovation.

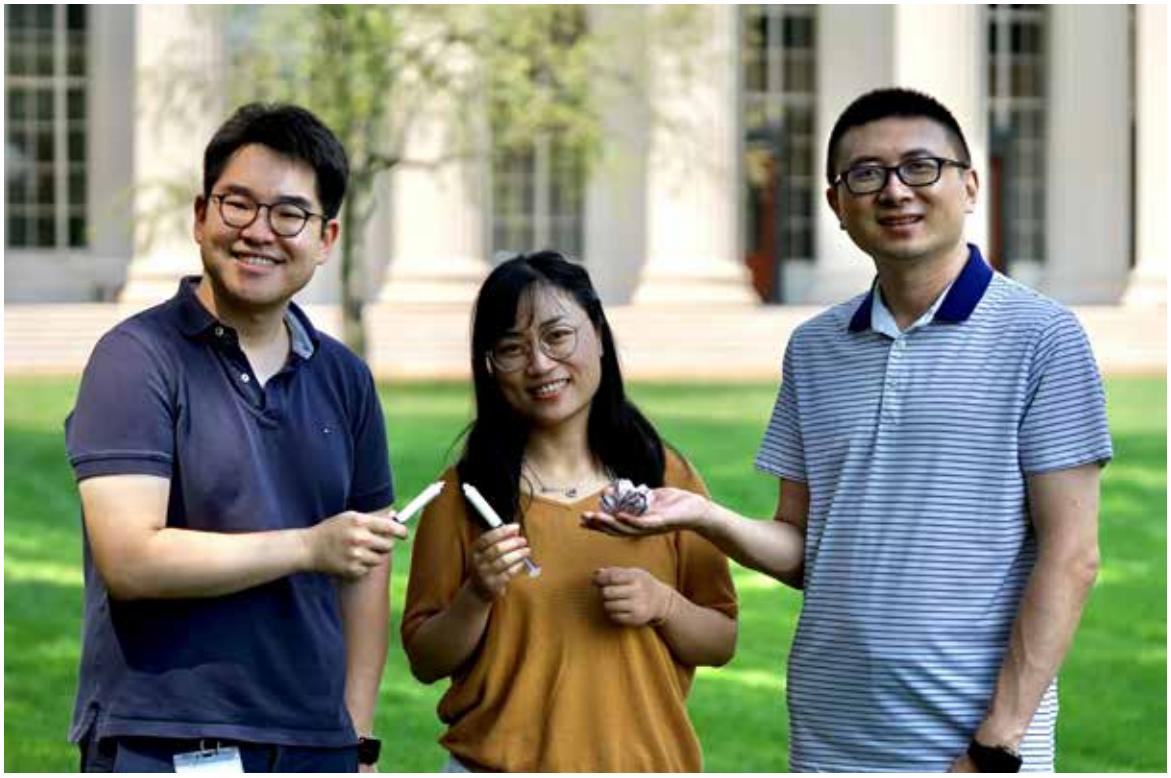

Photo: Courtesy of Hyunwoo Yuk

Hyunwoo Yuk and his fellow researchers mixed sticky micro-particles and silicone oil, to repel blood from tissue. The solution creates a strong seal around tissues and offers a breakthrough in performance beyond traditional approaches to controlling bleeding.

It turns out barnacles and animal and human body tissues are exposed to similar wet and unclean environments. Barnacles are exposed to water and dirt while animal and human body tissues are also wet and "dirty" due to their interaction with blood, which, by its nature is a contaminated fluid. The way barnacles manage to adhere to surfaces piqued the interest of Hyunwoo Yuk and his team of researchers.

They discovered that barnacles manage to adhere or cling to wet and dirty surfaces through sticky protein molecules suspended in an oil that repels water and contaminants. This function inspired Hyunwoo Yuk and his team to come up with a sticky solution that acts in a similar way and helps seal bleeding animal tissue.

Rather than using the actual protein that barnacles use for their test glue, they mixed sticky micro-particles and silicone oil, which repels blood from tissue. "For an adhesive to work you have to keep contaminated blood cells out of the way of tissue," explains Hyunwoo Yuk.

"From an engineering perspective, this kind of counterintuitive, out-of-the-box solution is important, as it can provide a breakthrough in performance beyond traditional approaches for stopping bleeding," he emphasizes.

WHAT SETS THIS INVENTION APART FROM OTHERS ON THE MARKET?

In a study published in *Nature Biomedical Engineering* (August 2021), Hyunwoo Yuk and his team demonstrated how their glue can stop bleeding in seconds. The experiment was conducted on rats with bleeding heart and liver injuries. Bleeding continued in the rats that Hyunwoo Yuk treated with standard products used by surgeons. For those treated with their oily glue, bleeding lasted ten seconds or so. Rats and pigs tested with the glue survived.

Besides saving time, Hyunwoo Yuk claims the innovation is also more robust than other similar products because it creates a stronger seal around tissues. In addition, he says the paste has the potential to work quickly on patients who are unable to form their own blood clots because of a medical condition. Existing solutions to stop dangerous bleeding rely on the body's natural ability to form blood clots. In conceptualizing their technology, the researchers wanted to stop bleeding without relying on blood clot formation at all. "In our view, relying on natural blood clot formation makes things slow and complicated and excludes patients with certain health conditions," says Hyunwoo Yuk.

NEXT STEPS TOWARDS COMMERCIALIZATION

While the startup is some time from being able to sign commercial deals, Hyunwoo Yuk says Asia and the United States will be potential big markets. In the meantime, the team is motivated to continue testing their barnacle-inspired glue.

With continued funding from corporate and private investors, the researchers plan to perform further pre-clinical studies on larger animals (pigs) to better optimize the technology for specific clinical indications as well as to gather necessary data toward investigative device exemption (IDE) from the United States Food and Drug Administration towards their first in-human clinical trial. They hope to be able to test their glue on humans in 18 months. Their focus will be on testing the capacity of their glue to stop blood flow during surgery on solid organs, (e.g. liver, spleen and kidney), cardiovascular surgery, as well as endoscopic surgery (gastrointestinal bleeding, and more). They also plan to explore demands in the military for application in treating gun wounds and impact injuries.

PROMISING POTENTIAL FOR PATIENTS AND CAREGIVERS

The evidence from the study of the glue's impact on bleeding animal tissue, although still in its early stages of development, offers hope for humans with blood, heart and liver disorders requiring surgery.

The glue has the potential to help cut down the time surgeons spend on controlling bleeding during surgeries. It could also prove useful in places without access to surgical resources like combat zones or resource-constrained regions.

While there is still some way to go before Mr. Yuk's invention comes out of the oven, the ingredients look promising. Certainly, millions of people will be hungry for it.

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Photo: Courtesy of Hyunwoo Yuk

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Hyunwoo Yuk

Hyunwoo Yuk on the importance of intellectual property

How is intellectual property important to your business?

Intellectual property (IP) is an essential part of a technology startup of any kind, as it is a core element to engage productively with larger companies and to attract much-needed investments. One of the first things companies and investors want to know is whether our technology is protected by a patent. Based on our experience so far, it is hard to imagine how we could do routine activities for next steps in commercialization without having our technologies and IP protected by patents.

How are you protecting your IP?

We protect our IP in the traditional way, by filing patents domestically and internationally. As it is common nowadays to translate lab-grown technologies into industries, educational effort and awareness of protecting IP beyond publishing academic papers has increased. Since protecting novelty and ownership of ideas against competitive peer researchers is so important in our academic career, it was kind of natural and easy for me to understand the importance of protecting IP in the form of a patent in our commercial setup.

What has been your experience with the patent filing process?

In the United States, initial provisional filing is fast and simple. It is easy to file a patent through technology licensing offices where a PCT application is commonly submitted with a national application to allow us to get protected internationally with priority. Formally filing a patent application requires substantially more time and often requires us to closely interact with a patent attorney and the school's technology licensing office to make sure the IP is commercially valuable enough to justify the legal cost.

Do you have an IP strategy?

We will incorporate MIT's larger IP strategy of grouping and integrating technologies that share core technologies to protect against infringement. While we are a bit too early stage for a detailed IP strategy, our startup will be defining this as a priority. I am learning that IP strategy, starting from license agreement terms (if spun-off from university technologies), can have a definitive impact on the overall commercialization process. We are carefully approaching this process with the help of experienced mentors and legal advisors.

What lessons have you learned so far around IP that you can share?

I have learned is that the patent is much more important than the research paper when it comes to commercialization of IP. While I have put a lot of effort into preparing strong patent applications for my recent inventions, I found that my earlier patents were somehow weaker as I was more focused on publishing academic papers than preparing strong patents. I have learned that a patent application is not and should not be a copy and paste of a research manuscript. It should also include commercial considerations on top of the technological aspects of the invention, including broad scope of claims, to prevent minor modification-based infringement, etc.