Medical Xpress

New, nanoporous ceramic filter offers hope to kidney-dialysis patients

March 29 2007

If you are one of the 370,000 Americans who lack functioning kidneys, you are all too familiar with the exhausting procedure of kidney dialysis. Three or four times every week, you visit a special clinic and sit for four hours as your blood is removed, cleaned and returned to your body.

Fatigue is your chronic companion. You may also experience low blood pressure, difficulty eating, muscle cramps and weight loss. And your arms and legs may be marked by numerous "port" sites from which your blood has been drawn.

All this you endure, for without dialysis to clean the toxins from your blood as your kidneys once did, you would not live more than a few days.

Today, however, hope is on the horizon – if not for a reprieve from dialysis, then at least for relief from its onerous side-effects.

William Van Geertruyden, who holds three degrees in materials science and engineering from Lehigh, has developed a new type of dialysis filter that, he says, represents the first major breakthrough in 30 years for dialysis patients.

Van Geertruyden, who earned a Ph.D. from Lehigh in 2004, has filed a patent application on a ceramic filter that he believes is dramatically superior to the traditional polymer, or rubber-like, filter used in dialysis.

Last September, his company, EMV Technologies, LLC, received a $195,000 Small Business Technology Transfer grant from the National Institutes of Health (NIH) to verify the feasibility of the new filter. EMV, which is located in Bethlehem, has received smaller grants from the Pennsylvania Keystone Innovation Zone (KIZ) program and the Ben Franklin Technology Partners.

The new ceramic filter has the potential to make kidney dialysis much more efficient, says Van Geertruyden, and to reduce by 30 minutes to one hour the time required for a dialysis treatment.

Specifically, the new filter promises to double the amount of toxins removed during dialysis and to double the glomulellar filtration rate (GFR), or rate of toxin removal. GFR is 100 percent in a normal person but only 15 percent at best for a dialysis patient, a rate that has changed little in the past 30 years.

The ceramic filter's secret, says Van Geertruyden, lies in its pores, which are organized in orderly rows and columns and which measure mere nanometers in diameter.

These nanopores, says Van Geertruyden, correspond more closely to the nano-sized toxins in the blood than do the larger pores of the standard dialysis filter. These polymeric pores vary in size and, when viewed with a microscope, appear in random arrangements of ovals, circles, slits and other shapes.

"Our goal is to double the amount of toxins removed during dialysis and to double GFR," says Van Geertruyden. "We base our confidence on the superior porosity of our medium.

"If we can improve the efficiency of filtration, we can improve mortality rate and quality of life."

Van Geertruyden founded EMV Technologies in 2003 with his Ph.D. adviser, Wojciech Misiolek, who is professor of materials science and engineering and director of Lehigh's Institute for Metal Forming.

EMV has established itself in forensic and failure analysis, mechanical property evaluation, and microstructural characterization and optimization. Its most noteworthy achievement is a technology that makes it easier to re-melt – and reuse – aluminum scraps by consolidating shavings, wires and other fine pieces of the metal into a bulk form that melts more readily.

EMV's foray into biomaterials began several years ago, when, as an adjunct professor at Widener College, Van Geertruyden met Zhongping Huang, an assistant professor of mechanical engineering.

"Huang told me about the polymer membrane that is used in kidney dialysis," says Van Geertruyden, "and we came up with the idea of a ceramic filter. We researched the market potential and studied the technical literature to find out whether our material was compatible in life-science applications.

"Everything checked out."

The company's NIH grant runs through 2007, by which time EMV expects to have developed a prototype that demonstrates the filter's improved efficiency. At that point, says Van Geertruyden, EMV will apply for a second NIH grant to run clinical trials on the filter.

Mimicking the function of an organ as wondrously complex as a kidney is no easy task.

Located on each side of the spine and measuring about the size of a fist, each kidney contains as many as one million nephrons, or filtering units.

Each nephron in turn contains a cluster of tiny blood vessels called a glomerulus, which is attached to a tubule. Every 24 hours, the kidneys filter about 200 quarts of fluid, returning 198 quarts of purified fluid to the bloodstream and excreting 2 quarts in the form of urine.

The toxins removed from the blood by the kidneys fall into two categories, says Van Geertruyden. Extracellular toxins are typically removed within the first half hour of dialysis. It usually requires the remainder of a four-hour dialysis session to rid the blood of intracellular toxins.

"Kidney patients do not die from dialysis but from cardiovascular diseases caused in part by nutrients being leaked out of the body," says Van Geertruyden. "Five years is the average survival rate for dialysis patients. We hope to improve that by targeting the bad stuff more precisely while leaving in the good stuff."

The new filter could also alleviate the stress resulting from the fast blood flow required to remove toxins and finish a dialysis treatment in four hours.

"To get a session done in four hours," says Van Geertruyden, "you have to be invasive in order to get a fast enough flow. If we can filter the toxins out faster, we won't need such a fast flow rate."

Partly because of an aging population, and partly because of the growing incidence of diabetes and high blood pressure, the number of kidney-dialysis patients in the U.S. is expected to jump to 620,000 in three years. This will place more strain on the hospitals and clinics equipped to do dialysis.

"If we can cut the time of an average session by just 30 minutes," says Van Geertruyden, "dialysis facilities can reduce the costs of labor and machine time, and accommodate more patients.

"That would be a tremendous improvement."

Source: Lehigh University

Citation: New, nanoporous ceramic filter offers hope to kidney-dialysis patients (2007, March 29) retrieved 26 April 2024 from https://medicalxpress.com/news/2007-03-nanoporous-ceramic-filter-kidney-dialysis-patients.html

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