COVID Information Commons (CIC) Research Lightning Talk

Transcript of a Presentation by Kaiming Ye (SUNY at Binghamton), April 15, 2022

Title: Ultraviolet Germicidal Irradiation for Disinfecting and Reuse of N95 Respirators

Kelly Dunning CIC Database Profile

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YouTube Recording with Slides

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Transcript

Kaiming Ye:

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Thank you for the very nice introduction. My name is Kaiming Ye. I'm the distinguished Professor at the SUNY Binghamton University. I'm also the chair of the Department of Biomedical Engineering, also the Director of the Center of Biomanufacturing for Regenerative Medicine.

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Let's see how I can go. Okay, so this is the NSF funded RAPID projects and the very beginning with on the COVID pandemic. This is the research team. So it's a collaborative research and between Binghamton University and Arizona State University. And the Binghamton teams included me and also Dr. Guy German, he is the Assistant Professor in the Department of Biomedical Engineering and a Ph.D. student Sebastian Freeman and he did all the work. And part of the - the COVID testing was performed by Dr. Karen Kibler at Arizona State University.

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So this is the problem we intend to solve with this grant and the award. And in the very early on in the pandemic so we are facing shortage of the PPE particularly, N95 masks. So we received a lot of requests from the local hospital and also the hospitals at other medical centers. They asked the simple question: is it possible to reuse N95 masks, by somehow disinfecting the virus that contaminated the masks. So we immediately thought about idea using the UVC - that's the UV light to disinfect the masks because we use the UVC all the time during cell cultures to disinfect any surface contaminated by the microorganism or the virus. And we design, I think, this is the device. Ok, so we designed several devices, and then to sterilize, to basically disinfect the virus.

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So the light we used is based on the UV lights. And if you look at it here there's three category of UV lights. And it's called the UV-A, they're usually in the very high wavelengths that's between 315 to 400 nanometers. And another category of the UV light called UV-B, 280 nanometers to 315 nanometers. Much lower wavelength of the UV, that's called a UV-C light and [that's] between the 100 to 280 nanometers. So this is a category of the lights we are much interested [in] because and those lights and particularly can destroy the DNA, if you look at the - on these panels - so the DNA-RNA the error have the thymine bases so they, on those bases, can absorb the UV-C light, the very short wavelength of the UV-C between the 100 to 200 nanometers, then formed, they're called the thymine dimers, when those dimers form, and the DNA-RNA will no longer be able to replicate. In other words, the cell, whatever the cell or virus, cannot be replicated. So in that way, the virus will be destroyed, because they have no capability of spreading among the cells and also infect the cells to destroy the cells. So that's the reason the UV-C lights [are] widely known as the germicide disinfectants. And because using the lights - it's very easy and compared to using chemicals, because we know a lot of people are thinking about using chemicals to disinfect the surface or using coating in antivirus chemicals on the surface to disinfect the bodies. But light is very easy and very shorter because usually you can disinfect the surface within minutes.

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So in the study we set up to - basically what we intend to discover is, what is the dose we need to eradicate the virus on the virus contaminated surface? Particularly very early on, we designed these devices. We sent these devices to the local hospital and a lot of medical centers. They used this system to sterilize, reuse N95 masks. Without knowing what is the right dose we require to completely eradicate the virus, but we, you know, in order to reach some efficiencies we use the extra light intensities. So basically, we use the more intensities than we should use. Then, the question we ask, that's the reason we talked to the NSF about the idea - said develop the model system, allow us to determine the appropriate dosage and level of the UV-C intensity, then we can base on that data to design the more efficient UV-C disinfecting devices. So this is the basically the process. I don't want to go through the entire design process, I just want to show you some results.

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So we did develop the devices. Basically, this is the homemade devices that allow us to check the intensity of the lights and also the power of the lights needed to - in order to completely eradicate the virus on any contaminated surface. Then we use these devices to determine the UV-C dose for eradicating the SARS-CoV-2, that's the virus COVID. So during this process, we discovered a very interesting phenomenon. When we suspend the virus in PBS buffer, that's literally just water, or we suspend the virus in the cell culture medium, that's the condition mostly people use when they determine the UV dosage for disinfections, we observe that completely two different dosage. If you look at it, if we suspend the virus SARS-CoV-2 in the water, the PBS buffer, they require more energy - less energy. Basically this is the less energy in order to completely eradicate the virus. If we suspend the virus in the cell culture medium, then we need a basically high energy in order to completely eradicate the virus contaminated surface. So then we ask the question: what factors played a critical role in disinfections?

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So we came up with the hypothesis. We basically say it's the medium in which the virus are suspended that plays the major role. Basically, it's the medium attenuating UV-C light and reducing the disinfection efficiencies. So in order to find out whether this is the case, we designed experiments and we used the model system.

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Now, instead of using the SARS-CoV-2, we used another retrovirus, basically a GFP expression retrovirus. Then we can, by detecting the GFP green fluorescence protein in the infected cells, then we can count how efficiently the virus infects the cells before and after UV-C disinfections. Then, we can use the automated system. We have the high content imaging system. We can use the automated high content imaging, we'll be able to very precisely quantify the reduction of the virus' infectivity before and after UV-C inspections. We examined - used the three different wavelengths. We're using the low wavelength 222 nanometers, we use the 254 nanometers UV-C, and 265 nanometers. So 254 nanometers: that's the UV-C light most people used, even before the pandemic, to disinfect any microorganism contaminated surface. The problem for 254 nanometers, because it generated ozone, that's the chemicals that have the very odd smell. And also if they reach a high concentration it is quite toxic. Then people discover 222 nanometers UV-C wavelengths, they do not generate the ozone and are much safer. But also cause damage to the human skin. So the reason we tested 265 nanometers is because most LED UV-C light bulbs emit the UV-C light at 265 nanometers, so we know to compare the 254 nanometers so LED is more energy efficient. And that's the reason we try to see what is the efficiency of the disinfection of the UV-C light and the different wavelengths. So again, we test the two different conditions. We suspend the virus in the cell culture medium and into the DPBS, that's basically water. So what we discover, we discover the UV-C light was attenuated significantly in the cell culture medium. If you look here, this is the DPBS buffer, this is the PBS buffer. This is basically the cell culture medium. Now, we try to find out what is the major component which the chemicals attenuate the UV-C light most. So then we check the - because all the cell culture medium, the major component of cell culture medium is the vitamin and also the amino acid serum. So we discover the serum this here PBS, that's the FBS that's a serum. So serum does not attenuate the UV-C very much. So it is the amino acid and also the right timing and attain the UV-C most. So we screened the number of the amino acids and also the number of the [?] timing. So we discover it's basically L-tryptophan and L-tyrosine. These two amino acids absorb UV-C light most and also one other, niacinamide, that's the vitamin that absorbs the UV-C light most. So what this discovery tells us, there is a potential we can use those amino acids and also the vitamin to develop the UV-C blockers. Because, remember, I mentioned to you one of the dangers of the UV-C light is to damage the human skin. That's why disinfection cannot be performed in the presence of humans. It has to be in the empty space. Humans have to leave the room before you can turn on a UV-C light to disinfect the surface. So this basically tells us we can there's potential to develop the UV-C block and use these three - two amino acids, mixed the two amino acids with the vitamin - so we'll be able to develop the blockers which can reduce the damage of the UV-C on the skin.

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Now, in the other study we try to understand to what extent the different cell culture medium, the medium where the virus suspended, really affected the UV-C efficiencies. We look at the salivas. The reason we look at saliva because most of the virus aerosolizes, usually, in saliva. Because when you

breathe out, you breathe out the virus. Virus is basically suspend in the saliva. So it's very important to understand how efficiently the UV-C light can disinfect and eradicate the virus when they are suspended in saliva. So this is the results. And you can see when viruses are suspended in the salivas, particularly in the short wavelengths and they are very, you know, very easy to disinfect, it is because this is, it shows, three [inaudible] on reduction of the virus infectivities after UV-C disinfections. So when they are suspended in the cell culture medium and they usually are very difficult to be less efficient and be disinfected. So that's basically another indication, another big observation we made through this grant, through this project. We determined, you know, saliva actually can attenuate on the - attenuate the UV-C light. That means in order to completely eradicate the virus we need to be using more energy and more high intensities

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And we also detected on the environment. So basically, light tests, because we know on, you know, the deeper and the light it penetrates and reaches to the surface of the - reach to the virus contaminated surface - the less efficiently UV-C can cure or eradicate the virus. So then, we detect what is efficient. What is the relationship between the live pass and of the UV-C efficient. And this is the data on [that] and we show you the result which is very clear. So the deeper the light passes the less efficient on the virus infections.

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So this is basically- and then based on this study, we developed a model system. And what this model system is used for is - this is now we have a system, we have a model, and this system can be used for anybody who wants to determine the efficiency of UV-C dosage required for eradicating the virus surface. And the model system can be used by the industry and they can use this model system to design their devices and also the model system can be used by the agencies if they want to regulate the UV-C products on a market. So that's basically the conclusion we draw from this study. Now we know, you know, what affected the UV-C efficiency and what the design criteria we need to follow when we design the system to determine the UV-C dosage for eradicating the virus, particularly SARS-CoV-2, and to reach the complete disinfection of a virus contaminated service. Thank you for listening.