Research Assessment Exercise 2020
Impact Case Study

University: City University of Hong Kong
Unit of Assessment (UoA): 8 materials science and materials technology

Title of case study: Development of portable histamine analyzer

(1) Summary of the impact

Histamine is found in certain foods and can produce severe reactions, such as asthma and hypotension, in the ~1% of individuals who suffer from intolerance. A cheap and reliable dietary histamine detector would thus significantly improve the safety and overall health of millions of people worldwide. A portable histamine detector has been developed based on research into receptor-analyte interactions. Funding of RMB20 million has been obtained from government and industry. As mentioned above
~1% world population can be benefitted from our easy to detect handheld device. Collaborative agreement has been made with "XMinnov Limited" through the project funded by State Oceanic Administration (China) and XMinnov employs 10 full time staff for large scale fabrication and commercialization of the project. As per the project agreement with State Oceanic Administration (China), the devices are distributed to Xiamen Entry-Exit Inspection and Quarantine Bureau for prescreening of histamine in food (details can be found from XMinnov supporting letter). A government funded project which is designed to impact the testing method of government organizations. A batch of 100 testing strips and 1 electronic unit was sent to the Entry-Exit Inspection and Quarantine Bureau in June 2018 and successive batches were sent for prescreening purposes.

(2) Underpinning research

The following City University staff led this research during the periods indicated:

- Dr. Vellaisamy A. L. Roy, Associate Professor of Materials Science and Engineering. (2013- Present)
- Prof. Michael H. W. Lam, Professor of Chemistry (2005- Present).

The following research staff and students contributed to this activity: Chi Chung Yeung (Senior Research Assistant): 2013-Present; Siu Chuen Lau (Senior Research Assistant): 2014 - 2016; Kam- Sing Chung (Research Assistant): 2014-2016; Shishir Venkatesh (PhD Student): 2015-2018; Christian Tuwahatu (Research Assistant): 2017-2018.

The impact is enabled by research undertaken at the City University of Hong Kong from 2005 to date. This has led to the development of a new sensing platform for affordable and on-site molecular detection. Key elements of the underpinning research include:

- Study of release and uptake of molecularly imprinted polymers for photo-regulatable azobenzene chromophore complexes [1, 5]
- Development of "general" bulk imprinted polymer synthesis method for molecular detection of phthalates and biogenic amines. [2, 3]
- Combination of bulk imprinted polymers with electrochemical transduction for an electrical output. [2, 3, 4, 6]
- Study to correlate different synthesis conditions of molecularly imprinted polymers with

their sensing properties in an electrochemical transduction device. [2]

- Development of a disposable testing strips containing molecularly imprinted polymers on flexible substrate compatible with large area manufacturing. [4]
- Development of the first pocket-sized on-site histamine analyzer, with smartphone control. [4]

(3) References to the research

This research has led to publications in well-respected international peer-reviewed journals such as Analytical Chemistry, Sensors & Actuators B: Chemical, and Journal of Materials Chemistry. Additionally, it has led to funding from the Hong Kong Government controlled Innovation and Technology Commission through 2 projects amounting to HKD 2.5 million.

Key References:

[1] Tang, Qian; Gong, Chengbin; Lam, Michael Hon Wah; Fu, Xiangkai. / Preparation of a photoresponsive molecularly imprinted polymer containing fluorine-substituted azobenzene chromophores. In: Sensors and Actuators B: Chemical. 2011 ; Vol. 156, No. 1. pp. 100-107

[2] Venkatesh, Shishir ; Yeung, Chi-Chung ; Sun, Qi-Jun ; Zhuang, Jiaqing ; Li, Tan ; Li, Robert K.Y. ; Vellaisamy A.L. Roy / Selective and sensitive onsite detection of phthalates in common solvents. In: Sensors and Actuators B: Chemical. 2018 ; Vol. 259. pp. 650-657

[3] A. L. Roy Vellaisamy, Ye Zhou ; Su-Ting Han / Electronic Device for Data Storage and a Method of Producing an Electronic Device for Data Storage. In: US patent application number 14/528,044

Other References:

[4] A. L. Roy Vellaisamy, Innovation & Technology Commission (ITC) Project # ITS/284/14FP - Electronic Sensor Array with Sensitive and Selective Detection of Amines for Food Safety: June 2015 – November 2016

[5] A. L. Roy Vellaisamy, Innovation & Technology Commission (ITC) Project # ITS/429/16FX - Electronic Sensors for Onsite Testing of Seafood: May 2017 – January 2019

[6] Tang, Qian ; Nie, Ying-Tian ; Gong, Cheng-Bin ; Chow, Cheuk-Fai ; Peng, Jing-Dong ; Hon- Wah Lam, Michael. / Photo-responsive molecularly imprinted hydrogels for the detection of melamine in aqueous media. In: Journal of Materials Chemistry. 2012; Vol. 22, No. 37. pp. 19812- 19820

[7] Venkatesh, Shishir ; Li, Tan ; Wang, Xiang-Sheng ; Yeung, Chi-Chung ; Pei, Ke ; Sun, Qi-Jun ; Wu, Wei ; Li, Robert K. Y. ; Lam, Michael H. W. ; Chan, Paddy K. L. ; Wylie, Jonathan J. ; Vellaisamy A. L. Roy. / Dual-Gated Transistor Platform for On-Site Detection of Lead Ions at Trace Levels. In: Analytical Chemistry. 2018; Vol. 90, No. 12. pp. 7399-7405

(4) Details of the impact

Context: Histamine, a naturally occurring chemical in food, is known to cause an

undesirable inflammatory response when consumed in large amounts. Approximately 1% of the world population has histamine intolerance, and so millions of people could benefit from a dietary histamine detection system that is cheap and easy-to-use. However, current histamine testing technologies use column separators and mass spectrometers and hence are not suitable for the non- expert due to cost, complexity and size. City University of Hong Kong has conducted research in sensing technologies, which has resulted in the creation of a new sensing platform suitable for non-

expert histamine detection. This new platform can be also exploited for molecular detection in other applications ranging from food quality analysis to disease diagnostics using simple testing protocols fit for lay use.

Pathways to Impact: The research described here has led to the development of a new sensing platform using molecular imprinted polymers (MIP). Essential to the sensing properties of MIP is the synthesis procedure. Work at City University of Hong Kong revealed the complex interplay between the MIP synthesis conditions and sensor performance. The understanding thus generated allowed MIP to be designed that resulted in sensor properties, such as detection limit and linear response range, which are suitable for practical applications (e.g. by being able to detect within a range relevant to regulatory limits). Finally, this sensing platform is used to produce an affordable and easy-to-use pocket-sized, semi-quantitative histamine analyzer for on-site testing of food.

Reach and Significance

Impact on MAST cell disorder/Histamine Intolerance (HIT) patients. The research team at City University of Hong Kong have been in contact with a voluntary group in UK where they have tried our devices for HIT patients. The smartphone-enabled histamine analyzer allows HIT patients to consume food within safe levels and avoid symptoms such as diarrhea, headache, rhino conjunctival symptoms, asthma, hypotension, arrhythmia, urticaria, pruritus, and flushing. More information can be found at https://mastcellblog.wordpress.com/2019/02/22/holygrail/

Impact on Government testing labs. Government testing lab (Xiamen Entry-Exit Inspection and Quarantine Bureau) in this case is a test and certification laboratory affiliated to the Government of the People's Republic of China. Presently, testing laboratories use complex mass spectrometer systems (LCMS) to test for histamines in food. This has handicapped the consumers since they have to wait several days for results. Consequently, this very critical test has become time-consuming and expensive. Having a pre-screening device that expedites testing would enable the testing lab to handle more tests at a given time. This would bring about an economic benefit to the testing labs. Also, having a direct (primary) end-user involved during the product development phase will help mitigate user interface and procedural issues that normally plague new technologies. Currently, our sensor module is used by the Government testing lab, Xiamen entry-exit port and team members are regularly meeting with the testing lab for feedback and design inputs for second development phase. Successful indication of government testing lab involvement is reflected in product design ease of operation by primary end-user.

Impact on XMinnov Ltd. XMinnov Ltd. is an IOT company based in Xiamen, China. They have been in partnership with Dr. Vellaisamy A. L. Roy's team to develop the portable histamine sensing unit since January 2016. After the fabrication of the first prototype version, they began the first round of beta-testing the smartphone-enabled histamine analyzer in early 2018 and completed the first-round beta-testing in mid-2018. The beta tests were performed at the Xiamen Entry-Exit Inspection and Quarantine Bureau, People's Republic of China. Based on the promising results of the first round, the company is preparing for a second round of beta testing with an improved design. The company estimates to launch the product through retail outlets in Q4, 2019 with expected sales of 10,000 units for the first year at a price of RMB 500/unit.

Impact on food industry and hotels. Currently, the food industry is completely dependent on

testing laboratories reports for food safety reports. However, as mentioned previously, this takes up a lot of their time and money. Sending samples to testing labs for test and waiting for results is impractical for food industry and hotels which is often an insignificant purchase for several food vendors. However, compliance failure can result in shutting down of business and heavy fines from regulatory bodies. An easy to operate pre-screening device greatly mitigates risk involved in purchase of food materials. The device allows them to perform a 'quick test' by themselves and help them make more informed business decisions. Not only would this bring about an economic benefit to the food and hotel industry but also it facilitates in weeding out sub-standard food suppliers. The device is modified for the so-called layman use in order for operation by the common people. The prototype has gone several design iterations with the involvement of our industry partners and is reflected in the product design ease of operation by a so-called 'layman' end-user.

(5) Sources to corroborate the impact

[A] Letter from the manufacturing partner Xiamen Innov Information Technology Co. Limited (XMinnov) confirming that research conducted in the City University of Hong Kong was crucial in the development of the testing strips used in the smartphone-controlled histamine sensing prototype.

Community and Outreach:

[A] Radio Television Hong Kong (RTHK) news article profiling the portable smartphone-controlled histamine sensing device (including an interview with Dr. Vellaisamy)
[B] South China Morning Post (SCMP) news article profiling the portable smartphone-controlled histamine sensing device.
https://www.scmp.com/presented/news/hong-kong/topics/food-safety-testing/article/2175129/handy-sensor-enhances-food
[C] Online blog post authored by a patient suffering from mast-cell disease who was approached for beta-testing the smartphone-controlled histamine testing device.
https://mastcellblog.wordpress.com/2019/02/22/holygrail/