京都大学教育研究振興財団助成事業
成　果　報　告　書

令和 03 年 04 月 22 日

公益財団法人京都大学教育研究振興財団
会 長　藤　　洋 作　様

所属部局	京都大学　エネルギー理工学研究所
職　　名	講師
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助成の種類	**令和 02 年度　・　研究活動推進助成**		
申請時の科研費研究課題名	DNA origami-based chemiresistive sensors for chemical and biological detections (DNAオリガミを利用して構築するケミレジスタセンサーの開発)		
上記以外で助成金を充当した研究内容	なし		
助成金充当に関わる共同研究者	(所属・職名・氏名)　なし		
発表学会文献等	(この研究成果を発表した学会・文献等) Delivered an Invited Lecture: A. Rajendran, Single molecular analysis of chemical and biological processes using DNA origami, International Conference on Recent Advancement in Chemical Sciences, Sona College of Technology, India, Online, 2020.8.10-14		
成果の概要	**研究内容・研究成果・今後の見通しなどについて、簡略に、A4版・和文で作成し、添付して下さい。(タイトルは「成果の概要／報告者名」)**		
会計報告	交付を受けた助成金額	1,000,000 円	
	使用した助成金額	1,000,000 円	
	返納すべき助成金額	0 円	
	助成金の使途内訳	費　目	金　額
		Chemicals for Synthesis	374,962
		Chemicals for Buffer	25,701
		Reagents and Solvents	343,127
		Enzymes	73,664
		Purification Systems	132,374
		Laboratory Consumables	40,733
		Others	9,439
当財団の助成について	(今回の助成に対する感想、今後の助成に望むこと等お書き下さい。助成事業の参考にさせていただきます。) I express my sincere gratitude for the research grant and supporting my research. The application process for the Kyodai-Zaidan was very simple, and there was a high degree of freedom regarding the use of subsidies. I could accomplish considerable achievements using this grant, and one of my research article is now in the revision stage and possibly it will be published soon. Most importantly, my application for FY2021 Kiban-C got accepted. I sincerely hope that this foundation will greatly help many other researchers for the development of future research.		

令和２年度京都大学教育研究振興財団

研究活動推進助成　「成果の概要」

令和 03年 04月 22日

成果報告者　京都大学エネルギー理工学研究所・講師 アリワラガン　ラジェンドラン

「成果の概要」　DNA オリガミを利用して構築するケミレジスタセンサーの開発

【研究内容】

In recent years, extensive research has been focused on the development of sensors for the detection of various analytes such as ions, gas molecules, common pollutants present in air and water, toxins in food chains, disease-causing microorganisms, clinically important biomolecules, and so on. The limitations of the current state-of-the-art sensors include the higher process time required for the detection, poor sensitivity and selectivity of the sensor, and in-flexibility of the sensor platforms for routine use. One notable example of these type of sensors is the chemiresistive sensor with the use of conjugated organic molecules or conducting polymers. In this type of sensors, the development of sensing material that has good mechanical flexibility, tunable conductivity, high sensitivity and selectivity for the analyte is very challenging. Further, a single sensing material/conducting polymer can′t be used for several analytes and it requires to develop analyte-specific sensing material for each detection. Further, the applications of these sensors are quite limited and seriously fail to distinguish analytes with similar properties/functionalities. For example, the chemiresistive sensors fail to differentiate pathogens vs non-pathogens, and fail to distinguish different cell types. This is mainly because of the lack of specific functional receptors in the conducting polymer which constitutes the sensing film. Thus, it is highly desirable to develop a sensor platform that uses a single sensing molecule for various analytes while maintaining all other prerequisites of a sensor. Hence, in this research, I aimed to develop the chemiresistive sensors that uses a single conducting polymer as a signal transducer while a DNA origami with functional receptor moieties as a sensing region. The same sensor system can be used for the detection of diverse analytes just by changing the functional moieties that are deliberately placed on the origami.

【研究成果】

One major issue with the origami nano-biomaterials is their unsatisfactory stability that prevents them from the applications in a wide range of conditions to withstand the thermal, mechanical and chemical modifications. Thus, the stability of DNA origami should be improved for the practical applications of sensor development. At first, we have carried out a detailed analysis for stabilizing the origami structures. For this purpose, we have adapted the enzymatic and chemical ligations of the discontinuities in the staple strands. The conditions for the ligation are now optimized. Our results indicated that we could successfully stabilize the DNA origami structures with the optimized conditions, and we could achieve the maximum ligation efficiency of about 75%. Further, the ligation is found to increase the stability of the DNA origami over 20°C, and also it is stable in the device fabrication conditions. Further, with the help of Prof. Praveen at IISc, India, the candidate conducting polymers are developed, and their abilities to incorporate in the chemiresistive sensors are investigated.

【今後の見通し】

Next, the bioconjugation strategies to link the conducting polymers and DNA origami will be developed. The incorporation of receptors on the DNA origami surface will then be studied. Once these functional materials are developed and combined to make the sensing films, they will be incorporated on the printed circuit board to produce the chemiresistive sensor. Then, finally the developed sensor will be used for sensing the clinically important biomolecules, and disease-causing microorganisms.