平成 30 年度　未来研究ラボシステム　研究成果報告書

研究種目：個人研究　　　　　　　　**研究期間**：平成 30 年 10 月～平成 31 年 9 月

研究課題名：色の変化できる素材を使って日常物の持続可能性を高める研究

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研究成果

This project taking the available of the color-changeable materials extend the range of recoloring applications; not only limited to the 3D printing [Punpongsanon et al. (2018)] and number of available color [Yamada Chemical Inc.]. In particular, this project focusing on two specific challenges; (1) **multi-color pixel pattern** that not limited to one color, but several color across the surface of the object by mixing multiple photochromic color, (2) the **range of application** in which extend from 3D printed object with specific customized hardware to commercial available hardware. Figure 1 shows the sample of mixing 3 available color-changeable inks; cyan, magenta, and yellow into a single ink that potential allows to manipulate different color within one single location by controlling exposition of light stimulus.

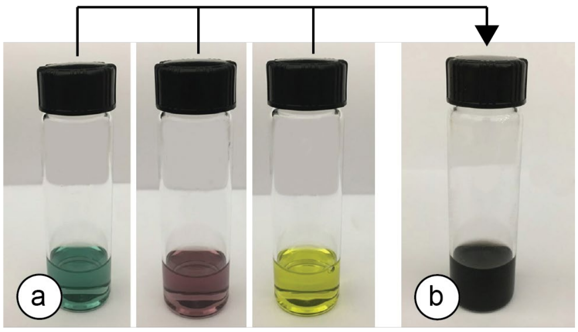

Figure 1. Mixing cyan, magenta, yellow into a black ink.

This report introduces a recent work in progress of this project, which are (1) *extending the range of available colors* by mixing several color-changeable inks and selectively exposing the color-changeable ink (called '*photochromic ink*', for the rest of this report) with specific wavelength as mentioned earlier in Figure 1, (2) *single material*, instead of fabricated multi-color voxel, the current progress allows multiple colors activated by a single printed with single material (using a UV resin). The *key contribution* of this work is mixing cyan (C), magenta (M), and yellow (Y) photochromic dyes (see: http://ymdchem.com/en/publics/index/87/ for details) into a single solution and leveraging the different absorption spectra of each dye (Figure 2), this method can control each color channel in the solution separately.

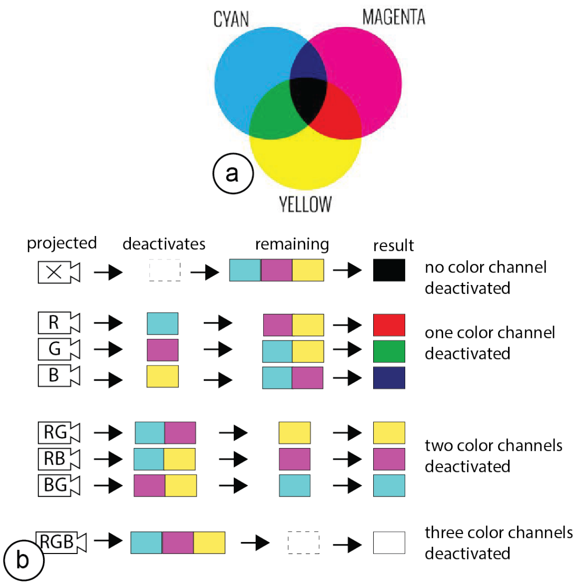

Figure 2. (a) CMY color scheme, (b) the predicted result of shining different combinations of RGB on the mixed CMY dye.

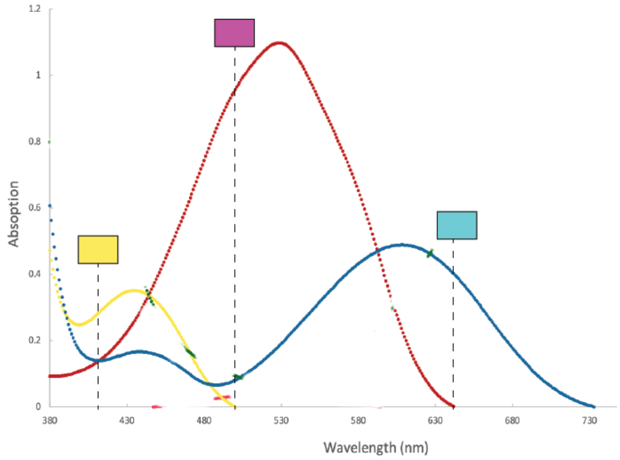

Figure 3. Deactivation wavelengths for each photochromic dye.

Extending the range of available color

The cyan, magenta, and yellow (CMY) color model enables a large range of colors by selectively blending three primary colors. This, in order to extend the range of color, the current approach is to selectively deactivate each photochromic color channel without affecting the other two channels. To do so, as can be seen in Figure 3, the deactivation peak is different for each photochromic color, i.e., the peak for cyan is at 640nm, or magenta at 470nm, and for yellow is at 350nm measured with spectrometer (Thorlabs CCD/CCS200 spectrometer). Thus, as long as the deactivation ranges are minimized, it is possible to control each color individually.

Single Material

Photochromic ink once diluted into a solution, can be mixed together. As shows in Figure 1, the characteristic black ink (see the details in Figure 2) that is created when mixing cyan, magenta, and yellow together. Since the mixture ink consolidates multiple colors in a single solution, it is allows to transform traditional single color fabrication processes into multi-color fabrication processes that create objects with re-programmable textures.

As of this report, this project success to combine the photochromic inks with a commercial UV-based 3D printer. Figure 4 shows the result of mixing photochromic colors, CMY, together and combining with transparent UV-sensitive resin for FormLabs (Form2) 3D printer. Since every voxels (specific location of the printed area) contains with multiple photochromic colors, it is possible to activate specific color with specific exposing light-wavelength.

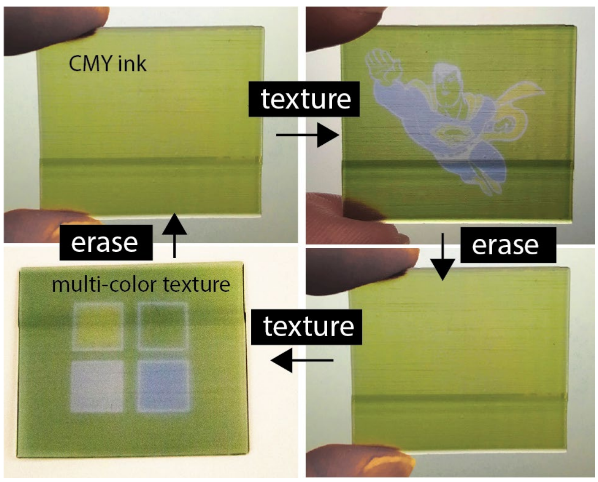

Figure 4. Mixing multiple photochromic colors together, here blue and yellow create green. Since every color has a different activation wavelength, we can activate and deactivate them separately, turning the green black into yellow or blue.

In the remaining steps, this project aims to extend the range of applications. In particular, with the *coating*, *painting*, and *textiles*. Fabric is typically printed on using silk screen printing. By mixing the photochromic dyes into a transparent screen-printable binder, it is possible to create clothing with reprogrammable multi-color textures with no added complexity to the process. In addition, mixing the ink into traditional coating solutions, users can simply spray them using an airbrush system. Integrating both potential applications, it is fulfill two specific challenges of this project.

キーワード：photochromic, digital fabrication, human-computer interaction

研究経費（H30 年度）の内訳

備品費	消耗品費	旅費	謝金	その他	合計
円	360,000 円	0 円	0 円	円	360,000 円

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発表論文等（平成 31 年 3 月 31 日現在）

研究代表者および主な共同研究者の研究業績のうち、本研究課題に関連するもののみを、現在から順に発表年次を過去に遡って記入してください。

〔学会発表〕

Martin Nisser, Junyi Zhu, Tianye Chen, Katarina Bulovic, Parinya Punpongsanon, Stefanie Mueller. Sequential Support: 3D Printing Dissolvable Support Material for Time-Dependent Mechanisms. In Proceedings of ACM Annual Conference in Tangible, Embedded, and Embodied Interaction (TEI) 2019, Arizona, USA, March 2019 (Full paper).

〔その他〕

Parinya Punpongsanon. Providing Target Haptics Sensation to Everyday Objects: From Digital to Physical Reality. ACM SIGCHI Asian Symposium 2018, Sendai, Japan, December 2018 (Invited Talk).

外部資金獲得状況・申請状況（本研究課題に関連して、科研費、JST 等の競争的資金、受託研究、奨学寄付金を受給された場合、また、申請された場合はその状況を記入ください）

該当なし

参考となるＨＰ等

https://www.sens.sys.es.osaka-u.ac.jp/