DU Journal of Undergraduate Research and Innovation

Volume 3, Issue 2, pp 56-63

Use of the smartphone as a handy colorimeter

Nisha Sella, Deepali Manchanda, Isha Gupta, Priya Bundela, Saloni Bansal, Seema Aggarwal, Bani Roy, Mallika Verma, Pratibha Jolly and Janaki Subramanyan*
Miranda House, University of Delhi, Delhi 110007
*janaki.subramanyan@mirandahouse.ac.in

ABSTRACT

An application (app), namely Mobile_My_Lab, was developed which could be used in smartphones to perform simple science experiments. A sensor in the app, the RGB (for red, green and blue light) sensor, was used as a colorimeter in biology experiments. The RGB sensor was used to study the degradation of starch by the enzyme salivary amylase, and to demonstrate dialysis using starch and iodine reagent. The transmittance in red light was recorded at regular intervals. In the salivary amylase experiment, the result obtained using the RGB sensor of the app was compared with that obtained when a colorimeter was used. The sensor method and colorimeter method gave similar results. With time, the intensity of blue-black colour decreased and accordingly the transmittance of red light increased.

In the dialysis experiment, starch (solution) was taken in the dialysis bag as the macromolecule and iodine in the water in which the bag was suspended was used as the micro molecules. Starch could not cross the dialysis membrane whereas iodine could. With time iodine molecules entered the dialysis bag and formed the starch-iodine complex, thereby increasing the intensity of the blue-black colour in the dialysis bag and gradually decreasing the transmittance. Each experiment was conducted four times, and the mean values were used to plot the graphs between time and transmittance in red light. The sensors in the app enable smartphones to be used as handy tools in the classroom in general and in promoting science education in a larger perspective.

Keywords: Amylase, colorimeter, dialysis, Mobile_My_Lab app, RGB sensor, smartphone

INTRODUCTION

Smartphones can be used to download/ install small programmes called applications (apps) and, therefore, can be used as scientific measuring instruments (1-6). The present study was conducted using the Mobile_My_Lab app, which is developed during the DU Innovation Project Mobile! My_Lab, anytime, anywhere (MH 305). The objective of the work was to use the RGB sensor as a colorimeter to measure the transmittance of a solution at periodic intervals to (i) study the degradation of starch by salivary amylase, and (ii) demonstrate dialysis using starch and iodine. The degradation of starch by salivary amylase was also studied using a colorimeter, and the results were compared with those obtained using the RGB sensor.

METHODOLOGY

Degradation of starch by salivary amylase

The experimental steps have been represented schematically in the figre given below (Figure-I A). The reaction between starch, the substrate for amylase present in saliva, and iodine resulted in a blue-black complex. The measuring cylinder placed in front of the camera of the stationary smartphone (Figure-II A) enabled recording the transmittance (7, 8) of the blue-black starch-iodine mixture containing salivary amylase in red light (red light is complementary to the blue-black complex) over a period of time. Using the RGB sensor in the MobileMyLab app, the degradation of starch by salivary amylase was monitored at 2-minute intervals up to 22 minutes (Table-I A). The experiment was also conducted using a colorimeter and with identical amounts of enzyme, substrate and iodine reagent as described previously; and the percent transmittance was recorded at 670 nm (red light) at 2-minute intervals up to 22 minutes (Table-I A). Controls were maintained and all experiments were replicated four times, and the standard deviation was calculated. The mean transmittance values (sensor method) and percent transmittance (colorimeter method) were used to plot graphs (Figure-III A, B).

Fresh saliva was diluted with an equal volume of distilled water.

↓

9 mL diluted saliva, 1 mL of 0.01% starch solution and 10 µL of iodine reagent (1.5%) were taken in a 10 mL measuring cylinder. The mixture turned blue-black.

↓

A Samsung S6 mobile phone (smartphone) was held at a stationary position using a selfie stick. The measuring cylinder was placed in front of the camera of the smartphone at a suitable distance.

↓

The smartphone was set on the MobileMyLab app, and the transmittance was recorded at 2-minute intervals up to 22 minutes using the RGB sensor of the app.

A dialysis bag containing 0.01% starch solution was prepared.

↓

The bag was suspended in a 500 mL beaker containing distilled water and a few drops of iodine reagent. The mouth of the beaker was covered with aluminium foil.

↓

A Samsung S6 mobile phone (smartphone) was held at a stationary position using a selfie stick. The beaker was placed in front of the camera of the smartphone at a suitable distance.

↓

The smartphone was set on the MobileMyLab app, and the transmittance was recorded at 3-minute intervals up to 21 minutes using the RGB sensor of the app.

Figure-I. Schematic representations. A (Left): Degradation of starch by salivary amylase; B (Right): Demonstration of dialysis.

Figure-IIA. The experimental setups. Degradation of starch by salivary amylase.

Figure-IIB. Demonstration of dialysis. The dialysis bag suspended in the beaker starts to turn blue-black as the iodine enters the bag.

Demonstration of dialysis

The protocol of the experiment is diagrammatically represented in Figure-I B. The iodine reagent imparted a yellow colour to the water in the beaker. The process of dialysis (9, 10) was studied by measuring the transmittance of the blue-black starch-iodine complex that was getting formed in the dialysis bag in red light at 3-minute intervals up to 21 minutes using the RGB sensor of the MobileMyLab app (Figure-II B, Table-I B). The experiment was replicated four times and the standard deviation was calculated. A graph was plotted using the mean transmittance values (Figure-IV). Controls with the dialysis bag containing water instead of starch solution were maintained to measure transmittance using the RGB sensor. The dialysis experiment could not be carried out using a colorimeter because of the limitations of the experimental setup.

RESULTS

Degradation of starch by salivary amylase

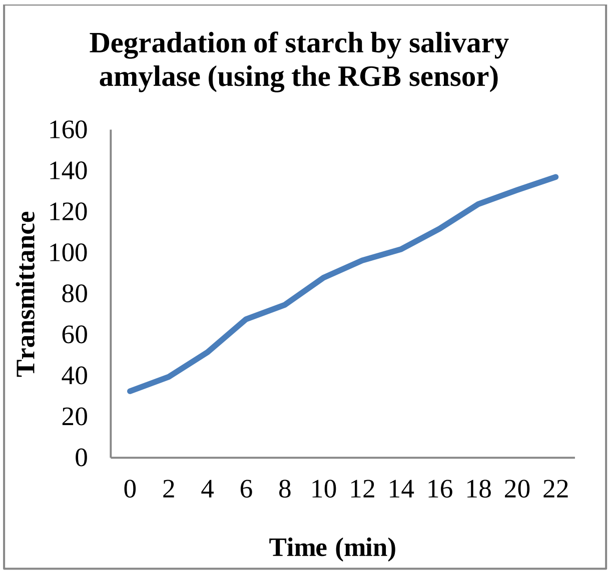
The degradation of the substrate starch by salivary amylase took place with the progression of time, resulting in a decrease in the intensity of blue-black colour of the mixture and a concomitant increase in the transmittance value in red light (Table-I). The trend of results obtained using the RGB sensor matched with that obtained when a colorimeter was used. In methods used, the transmittance of the control with only distilled water (9 mL), starch (1 mL) and iodine reagent (10 µL) remained almost constant over the 22-minute period. It ranged from 72.67 to 73.67 in the sensor method and 70.25 to 72.75 in the colorimeter method. The differences observed in the transmittance values were because of the colloidal nature of starch solution which did not allow complete homogeneity of the mixture.

Table-I. Detection of degradation of starch by salivary amylase by RGB sensor of MobileMyLab app and by measuring % transmittance at 670 nm using a colorimeter. Data given is the mean value ± standard deviation of transmittance.

Time (min)	Mean ± Standard Deviation	
	(Sensor method)	(Colorimeter method)
0	32.50 ± 5.59	30.50 ± 4.71
2	39.50 ± 5.31	34.25 ± 6.05
4	51.50 ± 3.50	36.00 ± 4.58
6	67.50 ± 7.69	39.50 ± 3.90
8	74.50 ± 5.85	43.00 ± 5.38
10	87.75 ± 6.49	44.00 ± 5.38
12	96.25 ± 10.42	48.25 ± 4.08
14	101.75 ± 8.70	51.50 ± 3.20
16	111.75 ± 7.49	54.75 ± 3.26
18	123.75 ± 13.50	58.00 ± 3.80
20	130.50 ± 14.94	61.75 ± 6.05
22	137.00 ± 14.08	66.50 ± 10.23

Table-II. Demonstration of dialysis. Mean value ± standard deviation of transmittance (sensor method) of four replicates.

Time (min)	Mean ± Standard Deviation (Sensor method)
0	119.00 ± 12.78
3	102.25 ± 18.92
6	93.50 ± 19.85
9	82.75 ± 24.03
12	73.75 ± 25.37
15	66.25 ± 19.96
18	57.75 ± 17.29
21	51.00 ± 14.35



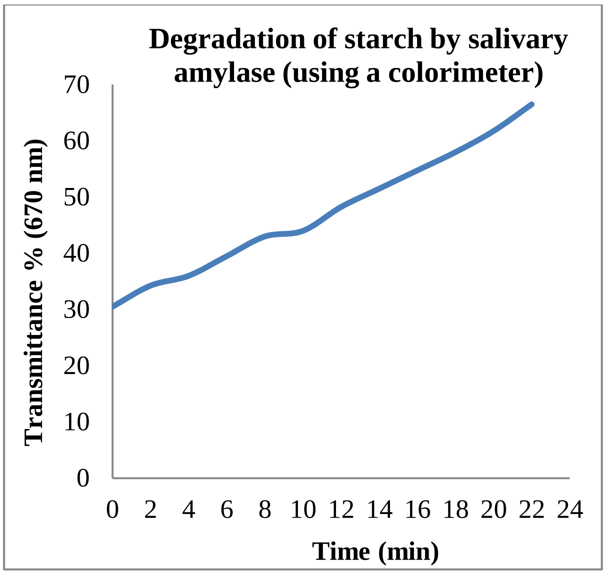


Figure-III. Measurement of degradation of starch by salivary amylase. A (Upper): Using the RGB sensor of MobileMyLab app; B (Lower): Using a colorimeter.

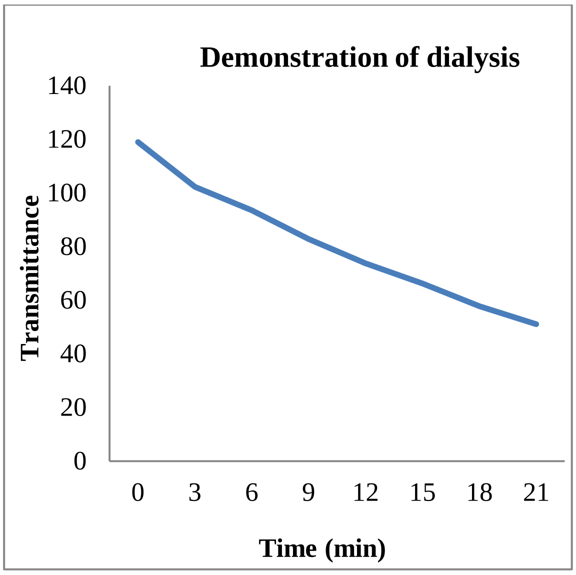


Figure-IV. Demonstration of dialysis using RGB sensor. As the dialysis proceeds, blue-black colour in the bag increases and the transmittance decreases.

Demonstration of dialysis

Initially the water in the beaker was yellow because of the iodine reagent, and the dialysis bag with the starch solution was almost colourless (Figure-II B). With time the dialysis bag started turning blue-black, thereby decreasing the transmittance of the contents of the dialysis bag (Table-II, Figure-IV). The transmittance of the control with water instead of starch in the dialysis bag was nearly constant, i.e. ranging between 118.5 and 120.0, during the 21-minute duration of the experiment.

DISCUSSION

Degradation of starch by salivary amylase

The plot of the transmittance versus time is nearly a straight line in both methods used (RGB sensor method and colorimeter method) showing that the two have a linear relationship (Figure-III A, B). In other words, as the activity of salivary amylase on the substrate starch progressed, the concentration and intensity of the blue-black starch-iodine complex decreased and the transmittance increased. Amylase present in the saliva degraded the starch and thus the colour of the solution gradually faded and ultimately became colourless. The results of the two methods follow a similar pattern.

It would be meaningful to study the progression of amylase activity at the same temperature in identical setups, one setup using the sensor method and the other using the colorimeter method. Such experiments would help in better comparison of the two methods, and further validate the reliability of the sensor method and the use of MobileMyLab app as a handy substitute of a colorimeter.

Demonstration of dialysis

Iodine being a micro molecles crossed the dialysis membrane and formed a blue-black complex with starch present in the bag. Starch being a macromolecule could not move out of the bag. With the formation of the starch-iodine complex the intensity of the blue-black colour in the bag increased. The transmittance accordingly decreased with time (Figure-IV).

CONCLUSIONS

The app that was developed enabled the use of the smartphone as a colorimeter. Simple experiments involving colorimetry can be conducted at schools and colleges without sufficient infrastructure using the app. The use of such handy educational tools would be a step forward to promote effective science education, especially in less privileged schools and in rural areas. The major advantage of the use of smartphones in the classroom is that teaching and learning can be carried out effectively without instruments, such as the colorimeter in our work, anytime and anywhere.

ACKNOWLEDGEMENTS

We gratefully acknowledge the financial support by the University of Delhi for the Innovation Project Mobile! Mylab Anytime, Anywhere (MH 305). Nisha Sella and Deepali Manchanda were student members from B.Sc. (Honours) Botany, and Isha Gupta, Priya Bundela and Saloni Bansal were from B.Tech. Computer Science. We sincerely thank Mr Vibhor Gupta, Founder & Director, Weekender Innovation Labs Pvt. Ltd, for helping us in developing MobileMyLab app. We thank the other student members in the Project, namely Manika Nagpal, Megha Pant, Nancy Suri, Nitya Gupta and Phroyia Pfuze, for their association.

REFERENCES

1. Kuntzleman, T. (2016, March 30). Use your smartphone as an absorption spectrophotometer. Retrieved from https://www.chemedx.org/blog/use-your-smartphone-absorption-spectrophotometer.

2. Williams, A.J. & Pence, H.E. (2011). Smart phones, a powerful tool in the Chemistry classroom. *Journal of Chemical Education, 88,* 683–686.

3. Maciel, T. (2015). Smartphones in the classroom help students see inside the black box. American Physical Society News *24* (3). Retrieved from https://www.aps.org/publications/apsnews/201503/smartphones.cfm

4. Kate. (2015, September 25). 3 Fabulous ways to use your smartphone in inquiry-based learning. Retrieved from http://www.aneverydaystory.com/2015/09/25/3-fabulous-ways-to-use-your-smartphone-in-inquiry-based-learning/

5. Subramanyan, J., Jolly, P., Manchanda, D. & Sella, N. (2016). Health sensors and smart medical devices. In: *Proceedings of the International conference on public health: issues, challenges, opportunities, prevention, awareness (Public Health 2016),* Vol. II, S. Roy, G.C. Mishra, S. Nanda and A. Jain (ed), New Delhi, India, Daulat Ram College, University of Delhi, Delhi, and Krishi Sanskriti, 15-16 January 2016, pp. 189-190 (ISBN 978-93-85822-10-10).

6. Pascu, T., White, M., Beloff, N., Patoli, Z. & Barker, L. (2013). Ambient health monitoring: the smartphone as a body sensor network component. In: *Innovation in medicine and healthcare,* Howlett et al (ed), Future Technology Press, pp. 62-65 (ISBN 978-0-9561516-3-6), imed 13-019. 7.

7. Plummer, D.T. (1978). An introduction to plant biochemistry, 2nd edn, New Delhi, India, Tata McGraw-Hill Publishing Company Ltd.

8. Wilson, K. & Walker, J. (ed). 2010. Principles and techniques of biochemistry and molecular biology, 7th edn, New Delhi, India, Cambridge University Press.

9. Sheeler, P. & Bianchi, D.E. (2002). Cell and molecular biology, 3rd edn, Kundli., India, John Wiley & Sons (Asia), Pvt. Ltd; printed and bound in India by Replika Press Pvt. Ltd.

10. Das, H.K. (2004). Textbook of biotechnology, New Delhi, India, Wiley Dreamtech India (P) Ltd.