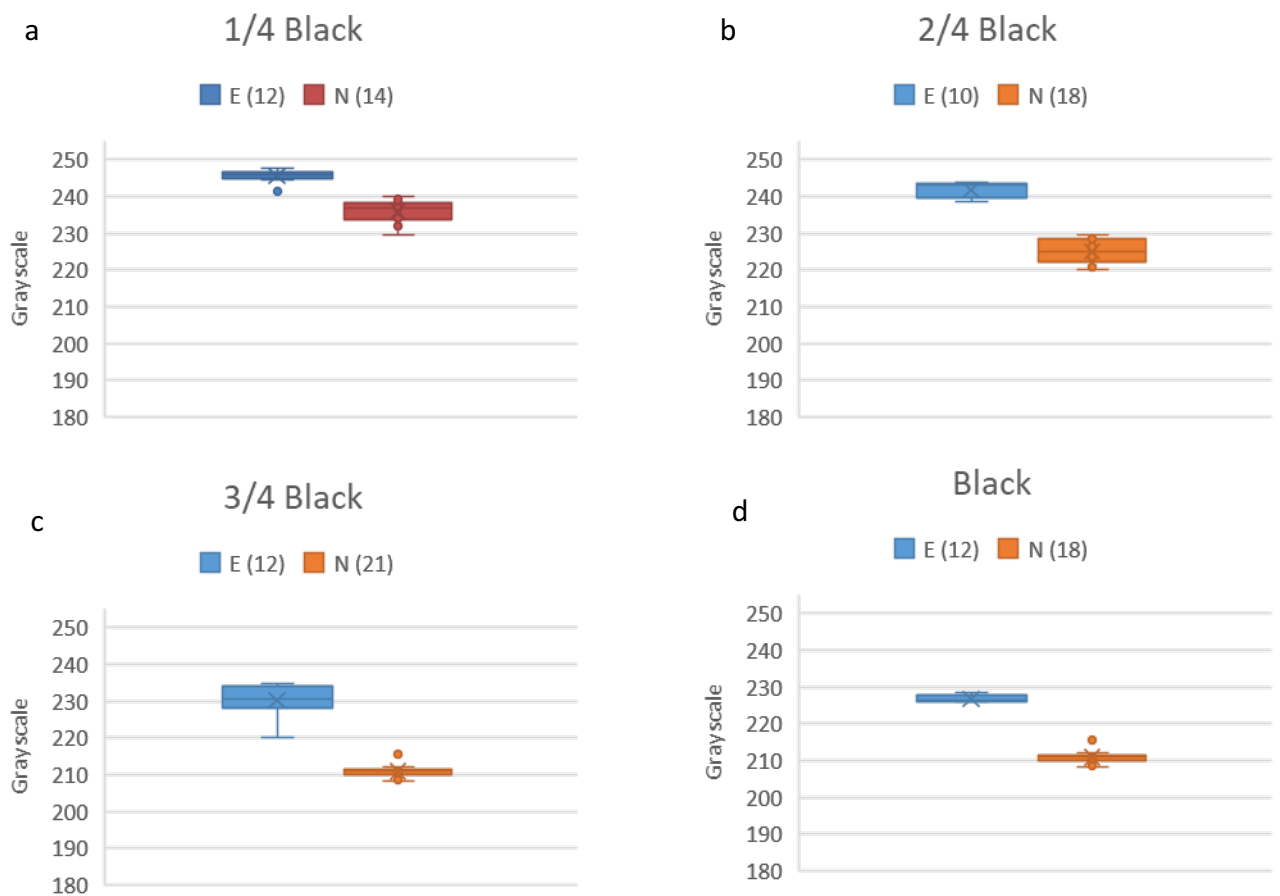
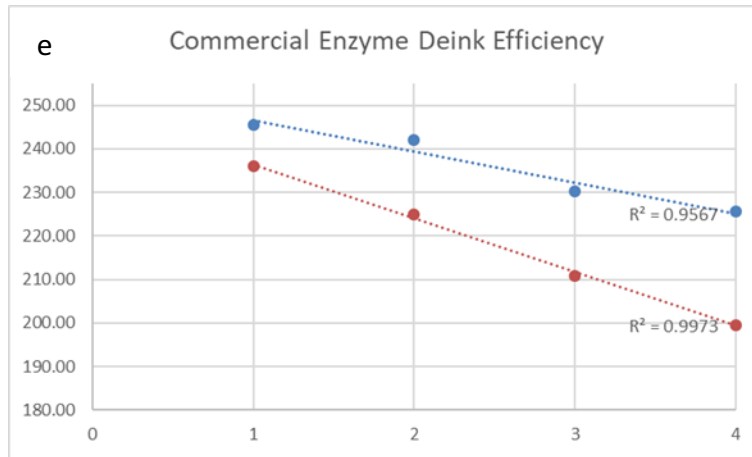


# Result

In order to speculate the efficiency of enzymatic deinking, we established the recycled paper process without enzymes in lab, first. Then, we compare the process we made with or without enzymes to confirm that the process with enzyme is better than one without enzymes. Our process can be briefly described in six parts, paper pulping, deinking, flotation and paper making. The enzymes, Xylanase, Glucanase and Lipase are added in deinking part, which is the key part to help the ink dropped off from paper. To determine our efficiency of the process with enzymes, we use same amount of commercial enzymes to react on the paper pulp made by the paper printed with the black surface area in the following ratio, 100%, 75%, 50% and 25% (Figure 1.). After the reprocessed paper made, we analyzed the grayscale of reprocessed paper to check the efficiency of our method with commercial enzymes. As the results, the reprocessed paper made with enzymes is brighter than the one without enzymes. The reprocessed paper made from the higher black surface area had greater grayscale between control and treatment group





**Figure 1. Enzyme deinking process in laboratory worked.**

a~d. Grayscale analysis of paper reprocess from pulp that made from paper printed 25%, 50%, 75%, 100% black with/ without enzyme deinking. e. Overall comparison of the difference between deink with or without enzymes. They are all deinked by commercial enzymes Xylanase, Lipase and Glucanase after pulping and treat for 1 hour at 60°C. After making the reprocessed paper, the reprocessed paper were scanned and analyzed the grayscale by imageJ. Based on 8-bit grayscale, value 0~255 represent standard score of black to white.

\*E. Enzymes were added into the pulp during deinking process; N. no enzyme was added into the pulp during deinking process.

**Table 1. Deinking efficiency of commercial enzymes in different pulp.**

**Mean**, the average grayscale of reprocessed paper; **SD**, the standard deviation of observations; **ink**, we standardize the mean of grayscale, and set the darkest level (all black paper pulp without enzyme treating) to 100, and the other in proportion; **deink(%)**, the deinking efficiency of enzyme.

E	1/4 Black(12)	2/4 Black(10)	3/4 Black(12)	Black(12)
Mean	245.64	241.94	230.24	225.64
SD	1.59	1.85	4.05	2.22
ink	7.02	12.62	30.33	37.30
deink(%)	14.68	25.58	29.41	39.47
N	1/4 Black(14)	2/4 Black(18)	3/4 Black(21)	Black(18)
Mean	235.94	225.04	210.80	199.56
SD	2.90	3.17	1.48	7.66
ink	21.71	38.19	59.75	76.76

The purpose of commercial enzyme efficiency testing is to compare the enzyme reaction effect between commercial and yeast secreted enzyme. So, we added yeast enzyme and repeated the reprocessed paper process, then analyze the grayscale.

**Table 2. Deink efficiency of yeast secreted enzyme.** After 5 hours yeast induction, the yeast secreted-out enzymes in medium were concentrated and added into paper pulp to reaction.

	Induced	Non-induced	PBS
Mean	243.34	237.82	235.83
SD	3.04	0.42	1.05
ink	10.50	18.85	21.87
deink(%)	11.37	3.02	0.00
recycle rate	0.47	0.50	0.54

It's necessary to confirm that the paper deinking process of device which we designed can work, so we deinked the paper first before paper pulping. After flotation, paper making, we analyzed the gray value of reprocessed paper to determine the efficiency of the enzyme that reacted on the paper fibers and inks.

**Table 3. Deink efficiency of commercial deink enzymes treat before pulping.**

Deinking before paper pulping and going through the others process. We mixed the commercial enzyme into a solution. The papers were passed through the solution and placed in a 60°C oven for 4 minutes. Then going through paper pulping, flotation and paper making, also, we analyzed the grayscale of paper.

Mean	250.13	220.84
SD	0.49	2.147
ink	0.22	44.56
deink(%)	44.34	
recycle rate	0.52	0.40

## Discussion

First, we added commercial enzymes to react on paper pulp with different black level to test enzyme effect. As the result, we can confirm that commercial enzymes have significant deinking effect. The linear relationship on Figure 1,e can be further explained that commercial enzyme can work on the paper printed with different amount of ink.

The next experiment is to use induced or non-induced yeast to concentrate the medium and treat enzymes on the paper pulp in deinking process, we can determine that the different between induced group and non-induced group. So we prove that enzymes which yeast produce have efficiency after induction.

Last, we conduct the experiment which modulates the working condition of enzyme as our device. Based on our design, the enzyme is induced to secrete out on the ink

part on the paper, which we think the working condition can be mimic by dipping the printed paper in the enzyme solution. Therefore, we compare the one soaking in the enzyme solution within three seconds or not. As the result, we find that this process can show the efficiency of enzyme more significant. So we think the enzyme secreted out by yeast will have a significant effect after going through the device we design.