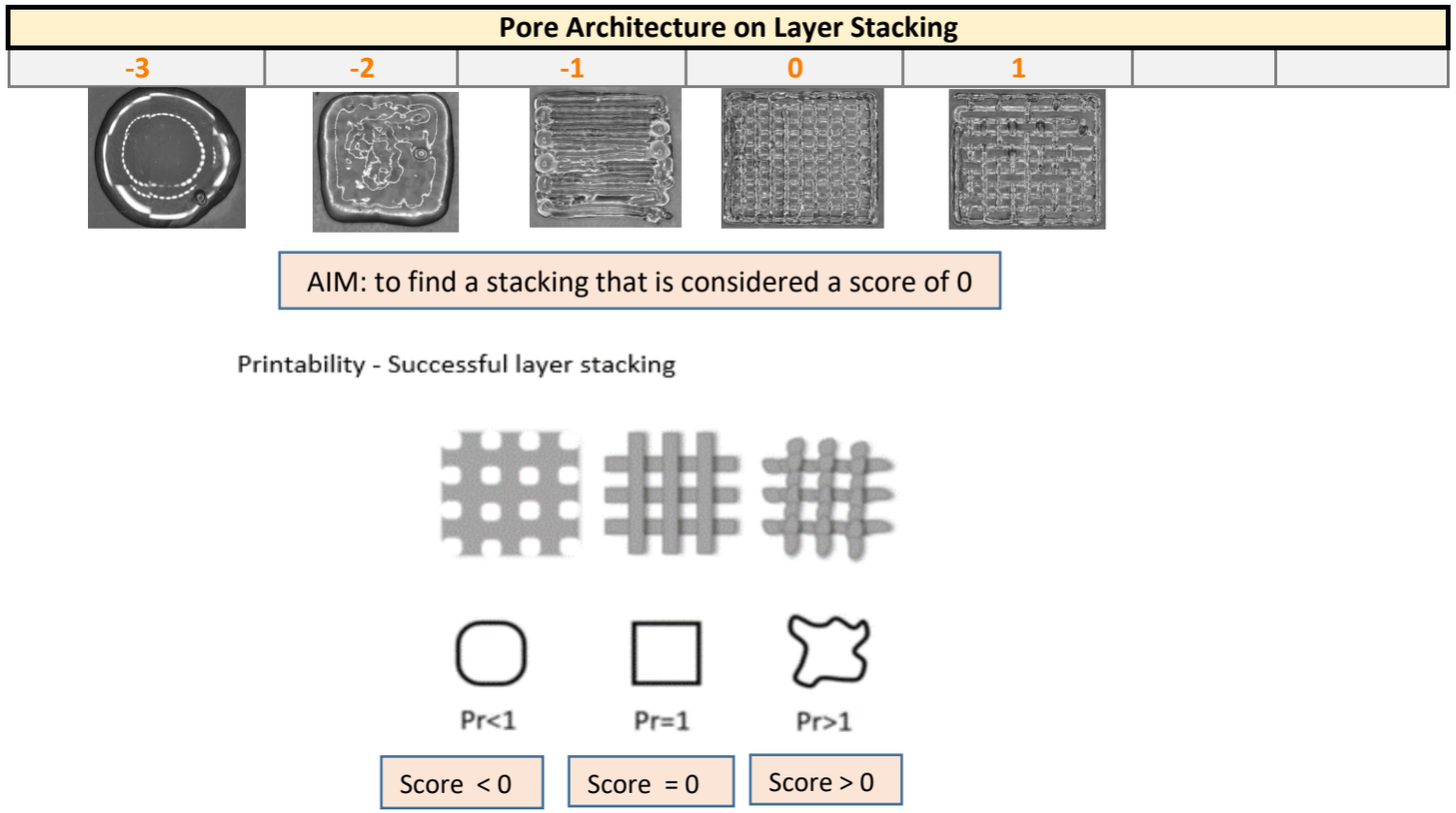
Supplementary Material

Coupling Machine Learning with 3D Bioprinting to Fast Track Optimisation of Extrusion Printing

Kalani Ruberu[a] Manisha Senadeera[b] Santu Rana[b] Sunil Gupta[b] Johnson Chung[a] Zhilian Yue[a] Svetha Venkatesh[b*] Gordon Wallace[a*]

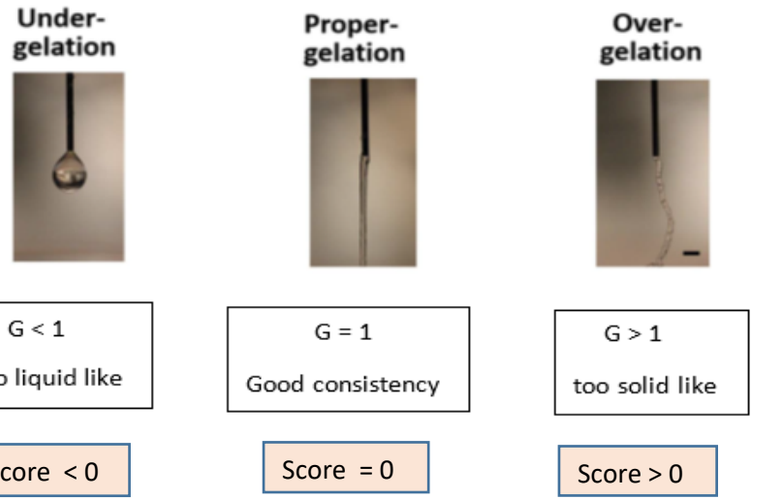
[a] Intelligent Polymer Research Institute, ARC Centre of Excellence for Electromaterials Science, AIIM Facility, Innovation Campus, University of Wollongong, NSW, Australia
[b] Applied Artificial Intelligence Institute (A^2I^2), Deakin University, Geelong, VIC, Australia



Filament Formation Scoring Scale						
-3	-2	-1	0	1	2	3

AIM: to find a fibre formation that is considered a score of 0

Printability - Fibre formation



REFERENCES

1 Ouyang, L., Yao, R., Zhao, Y., Sun, W. Effect of bioink properties on printability and cell viability for 3D bioplotting of embryonic stem cells. Biofabrication. 2016;8(3):035020.

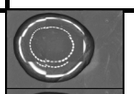
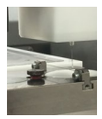
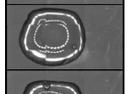
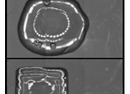
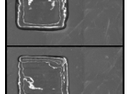
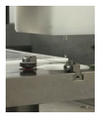
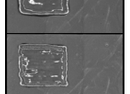
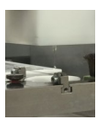
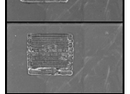
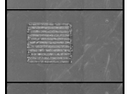
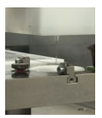
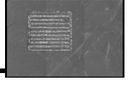
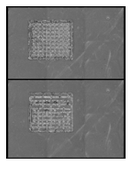
2 Paxton, N., Smolan, W., Bock, T., Melchels, F., Groll, J., Jungst, T. Proposal to assess printability of bioinks for extrusion-based bioprinting and evaluation of rheological properties governing bioprintability. Biofabrication. 2017;9(4):044107.

Supplementary Material : Scoring Experiments 1-12

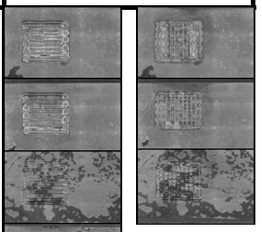
Preparation of GelMA (batch 3) - all 3 concentrations on 28-11-2018
Preparation of GelMA (batch 3)/ HAMA (batch 367) - all 3 concentrations on 28-11-2018
5% Irgacure 1:25 dilution (ie 0.2% final concentration)

Experiment Number : One

GelMA (filtered)

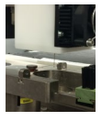
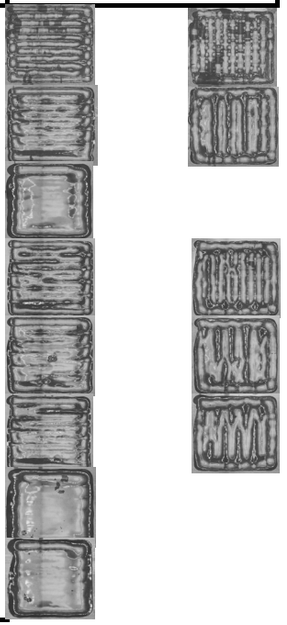
INPUT						OUTPUT			
Experiment Number	**GelMA %**	**Temperature (ink)**	**Pressure**	**Speed**	**Temperature (platform)**	**Fibre formation**		**Layer Stacking**	
1	5	22°C	3 bar	15 mm/s	10°C	-2		-3	
2	5	22°C	2.5 bar	20 mm/s	10°C	-1.5		-3	
3	5	22°C	2 bar	10 mm/s	10°C	-1		-3	
4	7.5	22°C	3 bar	10 mm/s	10°C	-1.9		-2.5	
5	7.5	22°C	2.5 bar	15 mm/s	10°C	-1.9		-2.5	
6	7.5	22°C	2 bar	20 mm/s	10°C	-1.9		-2.5	
7	10	22°C	3 bar	20 mm/s	10°C	-0.5		-1	
8	10	22°C	2.5 bar	10 mm/s	10°C	0		-0.3	
9	10	22°C	2 bar	15 mm/s	10°C	-1		-0.7	

GelMA & 2% HAMA combination

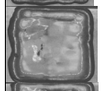
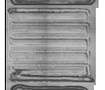
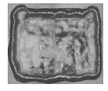
INPUT						OUTPUT			
Experiment Number	**GelMA %**	**Temperature (ink)**	**Pressure**	**Speed**	**Temperature (platform)**	**Fibre formation**		**Layer Stacking**	
1	10% GelMA, 2% HAMA	25°C	3.5 bar	10 mm/s	10°C	-0.1		-1.8	
2	10% GelMA, 2% HAMA	25°C	3 bar	8.5 mm/s	10°C	-0.1		-1.5	
3	10% GelMA, 2% HAMA	25°C	2.5 bar	10 mm/s	10°C	0		-0.4	
4	7.5% GelMA, 2% HAMA	25°C	3.5 bar	18 mm/s	10°C	-0.2		-2.7	
5	7.5% GelMA, 2% HAMA	25°C	3 bar	18 mm/s	10°C	-0.2		-2.5	
6	7.5% GelMA, 2% HAMA	25°C	2.5 bar	8 mm/s	10°C	-0.2		-2.4	
7	5% GelMA, 2% HAMA	25°C	3.5 bar	8 mm/s	10°C	-0.3		-2.8	
8	5% GelMA, 2% HAMA	25°C	3 bar	10 mm/s	10°C	-0.3		-2.5	
9	5% GelMA, 2% HAMA	25°C	2.5 bar	8 mm/s	10°C	-0.3		-2.4	

Experiment Number : Two

GelMA (filtered)

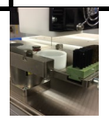
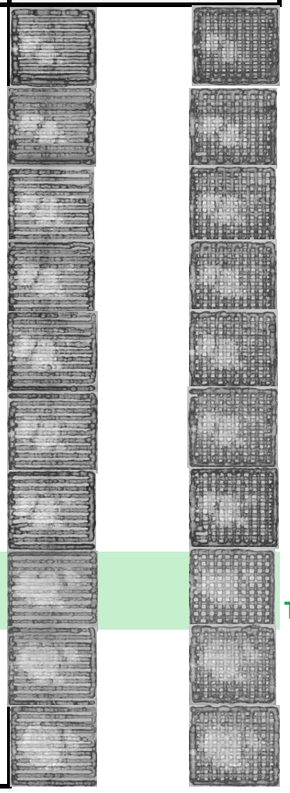
INPUT						OUTPUT			
Experiment Number	**GelMA %**	**Temperature (ink)**	**Pressure**	**Speed**	**Temperature (platform)**	**Fibre formation**		**Layer Stacking**	
1	10	25°C	2 bar	10 mm/s	10°C	-1.5		-1.1	
2	10	25°C	2 bar	12 mm/s	10°C	-1.5		-1.3	
3	10	25°C	2.9 bar	10 mm/s	10°C	-1.8	 	-1.9	
4	10	25°C	2 bar	20 mm/s	10°C	-1.5		-1.2	
5	10	25°C	2 bar	14.5 mm/s	10°C	-1.5		-1.6	
6	10	25°C	2 bar	17 mm/s	10°C	-1.5		-1.7	
7	10	25°C	3 bar	12.5 mm/s	10°C	-2		-2	
8	10	25°C	3 bar	20 mm/s	10°C	-2		-2	

GelMA & 2% HAMA combination

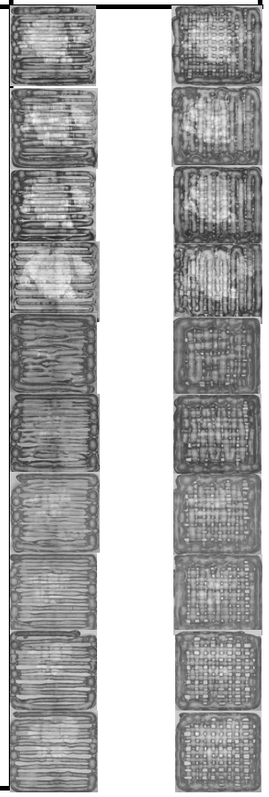
INPUT						OUTPUT			
Experiment Number	**GelMA %**	**Temperature (ink)**	**Pressure**	**Speed**	**Temperature (platform)**	**Fibre formation**		**Layer Stacking**	
1	10% GelMA, 2% HAMA	29°C	2.5 bar	11.5 mm/s	10°C	-0.6		-2.8	
2	10% GelMA, 2% HAMA	29°C	2.5 bar	8 mm/s	10°C	-0.6		-2.9	
3	10% GelMA, 2% HAMA	29°C	2.5 bar	14 mm/s	10°C	-0.6		-2.8	
4	5% GelMA, 2% HAMA	29°C	2.5 bar	13.5 mm/s	10°C	-0.4		-2.6	 
5	10% GelMA, 2% HAMA	29°C	2.5 bar	18 mm/s	10°C	-0.6		-2.7	
6	5% GelMA, 2% HAMA	29°C	2.5 bar	18 mm/s	10°C	-0.4		-2.6	 
7	10% GelMA, 2% HAMA	29°C	2.5 bar	10 mm/s	10°C	-0.6		-2.8	
8	5% GelMA, 2% HAMA	29°C	2.5 bar	10.5 mm/s	10°C	-0.4		-2.6	 

Experiment Number : Three

GelMA (filtered)

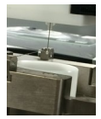
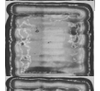
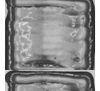
INPUT						OUTPUT			
Experiment Number	GelMA %	Temperature (ink)	Pressure	Speed	Temperature (platform)	Fibre formation		Layer Stacking	
1	10	22°C	2.4 bar	10 mm/s	10°C	0		-0.1	
2	10	22°C	2.5 bar	11 mm/s	10°C	0		-0.1	
3	10	22°C	2.6 bar	10 mm/s	10°C	0		-0.15	
4	10	22°C	2.5 bar	10.5 mm/s	10°C	0		-0.1	
5	10	22°C	2.4 bar	10.5 mm/s	10°C	0		-0.1	
6	10	22°C	2.6 bar	11 mm/s	10°C	0		-0.15	
7	10	22°C	2.3 bar	10 mm/s	10°C	0		-0.1	
8	10	22°C	2.4 bar	11.5 mm/s	10°C	0		0	TARGET
9	10	22°C	2.6 bar	10.5 mm/s	10°C	0		-0.15	
10	10	22°C	2.5 bar	11.5 mm/s	10°C	0		-0.1	

10% GelMA & 2% HAMA combination

INPUT						OUTPUT			
Experiment Number	**GelMA %**	**Temperature (ink)**	**Pressure**	**Speed**	**Temperature (platform)**	**Fibre formation**		**Layer Stacking**	
1	10% GelMA, 2% HAMA	25°C	2.5 bar	11 mm/s	10°C	-0.1		-0.5	
2	10% GelMA, 2% HAMA	25°C	2.6 bar	10 mm/s	10°C	-0.1		-0.8	
3	10% GelMA, 2% HAMA	25°C	2.5 bar	10.5 mm/s	10°C	-0.1		-0.6	
4	10% GelMA, 2% HAMA	25°C	2.6 bar	11 mm/s	10°C	-0.1		-0.6	
5	10% GelMA, 2% HAMA	25°C	2.6 bar	8.5 mm/s	10°C	-0.1		-0.8	
6	10% GelMA, 2% HAMA	25°C	2.5 bar	9.5 mm/s	10°C	-0.1		-0.7	
7	10% GelMA, 2% HAMA	25°C	2.6 bar	10.5 mm/s	10°C	-0.1		-0.7	
8	10% GelMA, 2% HAMA	25°C	2.6 bar	9.5 mm/s	10°C	-0.1		-0.7	
9	10% GelMA, 2% HAMA	25°C	2.5 bar	11.5 mm/s	10°C	-0.1		-0.45	
10	10% GelMA, 2% HAMA	25°C	2.5 bar	9 mm/s	10°C	-0.1		-0.5	

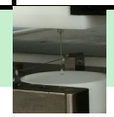
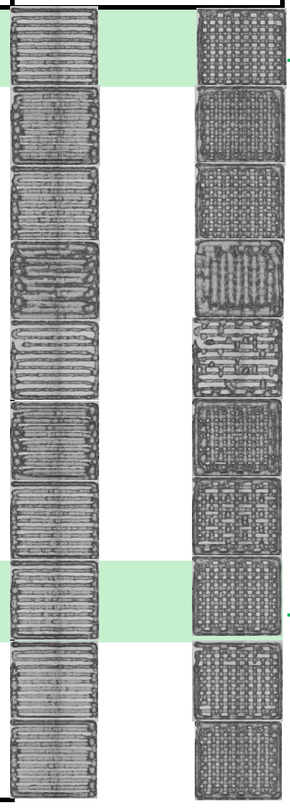
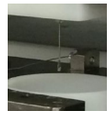
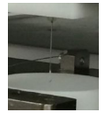
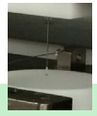
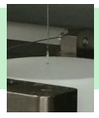
Experiment Number : Four - Preparation of GelMA (batch 3) - 5% concentration, 5% Irgacure 1:25 dilution on 06-09-2019

GelMA (filtered)

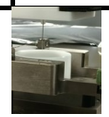
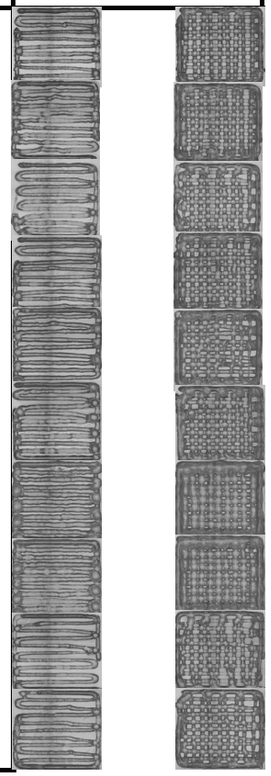
INPUT						OUTPUT			
Experiment Number	**GelMA %**	**Temperature (ink)**	**Pressure**	**Speed**	**Temperature (platform)**	**Fibre formation**		**Layer Stacking**	
1	5	21°C	2 bar	10 mm/s	10°C	-0.9		-2	
2	5	21°C	2 bar	13 mm/s	10°C	-0.9		-2	
3	5	21°C	2.2 bar	10 mm/s	10°C	-1		-2	
4	5	21°C	2.3 bar	13.5 mm/s	10°C	-1.2		-2	
5	5	21°C	2 bar	11 mm/s	10°C	-0.9		-2	
6	5	21°C	2.1 bar	10.5 mm/s	10°C	-1		-2	
7	5	21°C	2.1 bar	12 mm/s	10°C	-1		-2	
8	5	21°C	2.2 bar	11 mm/s	10°C	-1		-2	
9	5	21°C	2 bar	10.5 mm/s	10°C	-0.9		-2	
10	5	21°C	2.1 bar	10 mm/s	10°C	-1		-2	

Preparation of GelMA (batch 3) - 7.5% concentration, 5% Irgacure 1:25 dilution on 01-05-2020

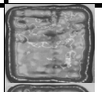
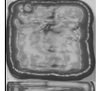
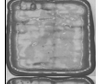
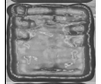
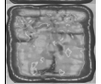
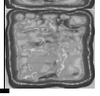
GelMA (filtered)

INPUT						OUTPUT				
Experiment Number	GelMA %	Temperature (ink)	Pressure	Speed	Temperature (platform)	Fibre formation		Layer Stacking		
1	7.5	20°C	2 bar	15.5 mm/s	10°C	0		0		TARGET
2	7.5	20°C	2.5 bar	10 mm/s	10°C	-0.1		-0.2		
3	7.5	20°C	2.5 bar	18 mm/s	10°C	-0.1		-0.1		
4	7.5	20°C	3 bar	10 mm/s	10°C	-0.15		-1		
5	7.5	20°C	2 bar	20 mm/s	10°C	0		0.2		
6	7.5	20°C	2.5 bar	14.5 mm/s	10°C	-0.1		-0.5		
7	7.5	20°C	2.1 bar	13 mm/s	10°C	0		0.1		
8	7.5	20°C	2.2 bar	16 mm/s	10°C	0		0		TARGET
9	7.5	20°C	2 bar	17.5 mm/s	10°C	0		-0.1		
10	7.5	20°C	2.1 bar	14.5 mm/s	10°C	0		-0.1		

10% GelMA & 2% HAMA combination

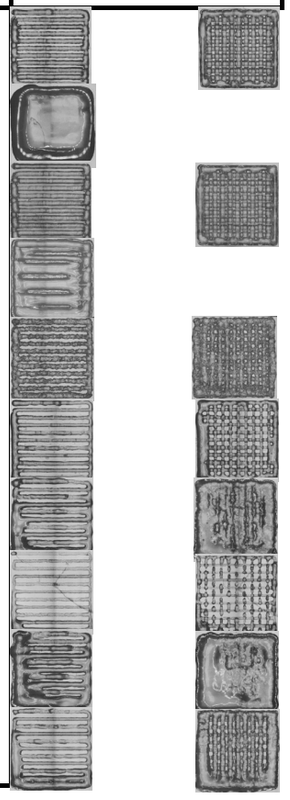
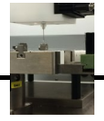
INPUT						OUTPUT			
Experiment Number	**GelMA %**	**Temperature (ink)**	**Pressure**	**Speed**	**Temperature (platform)**	**Fibre formation**		**Layer Stacking**	
1	10% GelMA, 2% HAMA	25°C	2.5 bar	8.5 mm/s	10°C	-0.1		-0.4	
2	10% GelMA, 2% HAMA	25°C	2.6 bar	9 mm/s	10°C	-0.1		-0.7	
3	10% GelMA, 2% HAMA	25°C	2.5 bar	12 mm/s	10°C	-0.1		-0.6	
4	10% GelMA, 2% HAMA	25°C	2.6 bar	11.5 mm/s	10°C	-0.1		-0.7	
5	10% GelMA, 2% HAMA	25°C	2.6 bar	8 mm/s	10°C	-0.1		-0.7	
6	10% GelMA, 2% HAMA	25°C	2.5 bar	8 mm/s	10°C	-0.1		-0.7	
7	10% GelMA, 2% HAMA	25°C	3 bar	8 mm/s	10°C	-0.1		-0.8	
8	10% GelMA, 2% HAMA	25°C	3 bar	9 mm/s	10°C	-0.1		-0.8	
9	10% GelMA, 2% HAMA	25°C	2.5 bar	12.5 mm/s	10°C	-0.1		-0.6	
10	10% GelMA, 2% HAMA	25°C	2.6 bar	12 mm/s	10°C	-0.1		-0.6	

GelMA & 2% HAMA combination

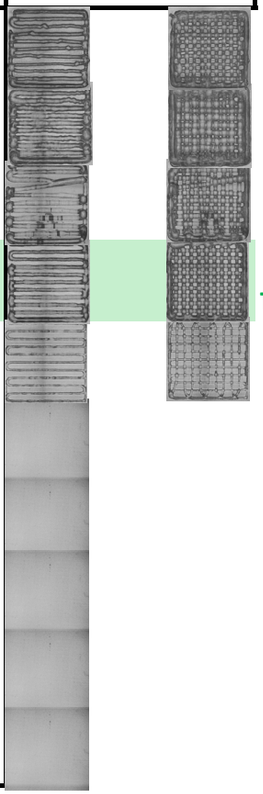
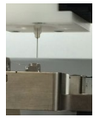
INPUT						OUTPUT			
Experiment Number	**GelMA %**	**Temperature (ink)**	**Pressure**	**Speed**	**Temperature (platform)**	**Fibre formation**		**Layer Stacking**	
1	5% GelMA, 2% HAMA	25°C	2.7 bar	13 mm/s	10°C	-0.3		-2.8	
2	5% GelMA, 2% HAMA	25°C	3.3 bar	13 mm/s	10°C	-0.4		-2.9	
3	7.5% GelMA, 2% HAMA	25°C	2.7 bar	16.5 mm/s	10°C	-0.3		-2.7	
4	5% GelMA, 2% HAMA	25°C	2.6 bar	10.5 mm/s	10°C	-0.3		-2.9	
5	5% GelMA, 2% HAMA	25°C	2.5 bar	12 mm/s	10°C	-0.3		-2.8	
6	5% GelMA, 2% HAMA	25°C	2.5 bar	13.5 mm/s	10°C	-0.3		-2.8	
7	5% GelMA, 2% HAMA	25°C	2.5 bar	9.5 mm/s	10°C	-0.3		-2.9	
8	5% GelMA, 2% HAMA	25°C	2.6 bar	8.5 mm/s	10°C	-0.3		-2.9	
9	5% GelMA, 2% HAMA	25°C	2.5 bar	10.5 mm/s	10°C	-0.3		-2.8	
10	5% GelMA, 2% HAMA	25°C	2.5 bar	9 mm/s	10°C	-0.3		-2.8	

Experiment Number : Five - Search space expansion

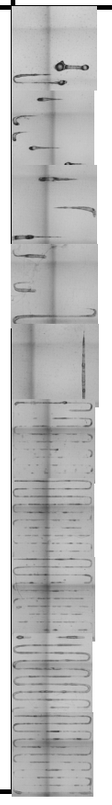
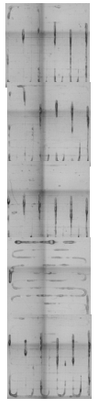
GelMA (filtered)

INPUT						OUTPUT			
Experiment Number	**GelMA %**	**Temperature (ink)**	**Pressure**	**Speed**	**Temperature (platform)**	**Fibre formation**		**Layer Stacking**	
1	5	20°C	1.0 bar	10 mm/s	10°C	-0.5		-0.2	
2	5	20°C	3.4 bar	10 mm/s	10°C	-1.2		-2	
3	5	20°C	1.0 bar	12.5 mm/s	10°C	-0.5		-0.4	
4	5	20°C	1.4 bar	10 mm/s	10°C	-1		-1	
5	5	16°C	3.8 bar	11 mm/s	10°C	0.5		0.2	
6	5	15°C	1.0 bar	8 mm/s	25°C	-0.2		-0.1	
7	5	15°C	4.0 bar	20 mm/s	25°C	0		-0.9	
8	5	15°C	1.0 bar	20 mm/s	25°C	-0.2		-0.5	
9	5	15°C	3.9 bar	8 mm/s	25°C	0		-1	
10	5	15°C	2.5 bar	14 mm/s	25°C	-0.1		-0.6	

GelMA & 2% HAMA combination

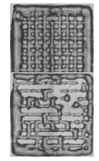
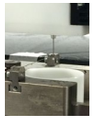
INPUT						OUTPUT			
Experiment Number	**GelMA %**	**Temperature (ink)**	**Pressure**	**Speed**	**Temperature (platform)**	**Fibre formation**		**Layer Stacking**	
1	10% GelMA, 2% HAMA	25°C	2.9 bar	9.5 mm/s	10°C	0		-0.4	
2	10% GelMA, 2% HAMA	25°C	3.1 bar	9.5 mm/s	10°C	0		-0.8	
3	10% GelMA, 2% HAMA	25°C	2.4 bar	10 mm/s	10°C	0		-0.5	
4	10% GelMA, 2% HAMA	25°C	2.6 bar	12.5 mm/s	10°C	0		0	TARGET
5	10% GelMA, 2% HAMA	25°C	1.5 bar	8.5 mm/s	10°C	1		1	
6	10% GelMA, 2% HAMA	15°C	1.0 bar	8 mm/s	25°C	3		3	
7	10% GelMA, 2% HAMA	15°C	1.0 bar	12 mm/s	25°C	3		3	
8	10% GelMA, 2% HAMA	15°C	1.0 bar	15 mm/s	25°C	3		3	
9	10% GelMA, 2% HAMA	15°C	1.0 bar	17.5 mm/s	25°C	3		3	
10	10% GelMA, 2% HAMA	15°C	1.0 bar	10 mm/s	25°C	3		3	

GelMA & 2% HAMA combination

INPUT						OUTPUT			
Experiment Number	**GelMA %**	**Temperature (ink)**	**Pressure**	**Speed**	**Temperature (platform)**	**Fibre formation**		**Layer Stacking**	
1	5% GelMA, 2% HAMA	15°C	1.0 bar	8 mm/s	10°C	2.8		2.7	
2	5% GelMA, 2% HAMA	15°C	1.0 bar	12 mm/s	10°C	2.8		2.7	
3	5% GelMA, 2% HAMA	15°C	1.0 bar	15 mm/s	10°C	2.8		2.8	
4	5% GelMA, 2% HAMA	15°C	1.0 bar	17.5 mm/s	10°C	2.8		2.9	
5	5% GelMA, 2% HAMA	15°C	1.0 bar	10 mm/s	10°C	2.8		2.7	
6	5% GelMA, 2% HAMA	15°C	1.0 bar	8 mm/s	25°C	2.8		2.5	
7	5% GelMA, 2% HAMA	15°C	1.0 bar	12 mm/s	25°C	2.8		2.5	
8	5% GelMA, 2% HAMA	15°C	1.0 bar	15 mm/s	25°C	2.8		2.5	
9	5% GelMA, 2% HAMA	15°C	1.0 bar	17.5 mm/s	25°C	2.8		2.5	
10	5% GelMA, 2% HAMA	15°C	1.0 bar	10 mm/s	25°C	2.8		2.5	

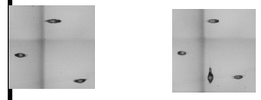
Experiment Number : Six

GelMA (filtered)

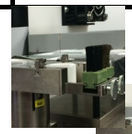
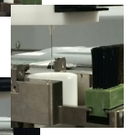
INPUT						OUTPUT			
Experiment Number	GelMA %	Temperature (ink)	Pressure	Speed	Temperature (platform)	Fibre formation		Layer Stacking	
1	5	21°C	1.0 bar	10.5 mm/s	10°C	-0.6		-1.8	
2	5	21°C	1.0 bar	8.5 mm/s	10°C	-0.6		-2	
3	5	21°C	1.0 bar	12 mm/s	10°C	-0.6		-1.5	
4	5	21°C	1.2 bar	10.5 mm/s	10°C	-0.8		-2	
5	5	21°C	1.0 bar	9.5 mm/s	10°C	-0.6		-2	
6	5	15°C	1.3 bar	9 mm/s	25°C	-0.2		-0.2	
7	5	15°C	1.0 bar	9.5 mm/s	25°C	-0.2		-0.8	
8	5	15°C	2.3 bar	12.5 mm/s	25°C	-0.2		-1	
9	5	15°C	1.2 bar	8 mm/s	25°C	-0.2		-0.4	
10	5	15°C	1.1 bar	8.5 mm/s	25°C	-0.2		-0.2	

Preparation of 5% & 7.5% GelMA:HAMA using GelMA batch 3 & HAMA 367, 5% Irgacure 1:25 dilution on 29-10-2019

GelMA & 2% HAMA combination

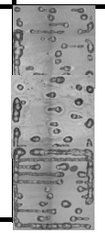
INPUT						OUTPUT			
Experiment Number	**GelMA %**	**Temperature (ink)**	**Pressure**	**Speed**	**Temperature (platform)**	**Fibre formation**		**Layer Stacking**	
1	7.5% GelMA, 2% HAMA	15°C	1.0 bar	8 mm/s	10°C	3		3	
2	7.5% GelMA, 2% HAMA	15°C	1.0 bar	12 mm/s	10°C	3		3	
3	7.5% GelMA, 2% HAMA	15°C	1.0 bar	15 mm/s	10°C	3		3	
4	7.5% GelMA, 2% HAMA	15°C	1.0 bar	17.5 mm/s	10°C	3		3	
5	7.5% GelMA, 2% HAMA	15°C	1.0 bar	10 mm/s	10°C	3		3	
6	7.5% GelMA, 2% HAMA	15°C	1.0 bar	8 mm/s	25°C	3		3	
7	7.5% GelMA, 2% HAMA	15°C	1.0 bar	12 mm/s	25°C	3		3	
8	7.5% GelMA, 2% HAMA	15°C	1.0 bar	15 mm/s	25°C	3		3	
9	7.5% GelMA, 2% HAMA	15°C	1.0 bar	17.5 mm/s	25°C	3		3	
10	7.5% GelMA, 2% HAMA	15°C	1.0 bar	10 mm/s	25°C	3		3	

GelMA & 2% HAMA combination

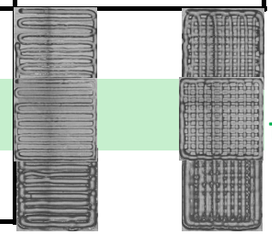
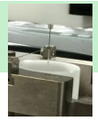
INPUT						OUTPUT			
Experiment Number	**GelMA %**	**Temperature (ink)**	**Pressure**	**Speed**	**Temperature (platform)**	**Fibre formation**		**Layer Stacking**	
1	5% GelMA, 2% HAMA	25°C	2.2 bar	8 mm/s	11°C	-0.2		-1.8	
2	5% GelMA, 2% HAMA	25°C	1.3 bar	8 mm/s	11°C	-0.15		-0.5	
3	5% GelMA, 2% HAMA	25°C	1.8 bar	8 mm/s	11°C	-0.2		-1.5	
4	5% GelMA, 2% HAMA	25°C	2.0 bar	9 mm/s	11°C	-0.2		-1.7	
5	5% GelMA, 2% HAMA	25°C	1.6 bar	9.5 mm/s	11°C	-0.1		-1.5	

Experiment Number : Seven

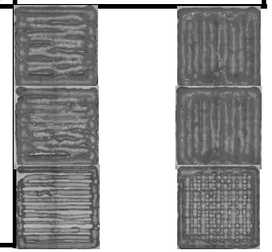
GelMA (filtered)

INPUT						OUTPUT			
Experiment Number	**GelMA %**	**Temperature (ink)**	**Pressure**	**Speed**	**Temperature (platform)**	**Fibre formation**		**Layer Stacking**	
1	5	19°C	0.8 bar	10.6 mm/s	10°C	0.1		2	
2	5	19°C	0.7 bar	9.4 mm/s	10°C	0.1		2	
3	5	19°C	1.0 bar	10.7 mm/s	10°C	0.1		1.7	

GelMA & 2% HAMA combination

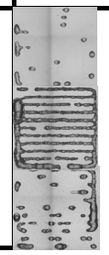
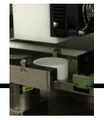
INPUT						OUTPUT			
Experiment Number	GelMA %	Temperature (ink)	Pressure	Speed	Temperature (platform)	Fibre formation		Layer Stacking	
1	5% GelMA, 2% HAMA	25°C	1.3 bar	8 mm/s	11°C	-0.2		-0.5	
2	5% GelMA, 2% HAMA	25°C	1.0 bar	9 mm/s	11°C	0		0	TARGET
3	5% GelMA, 2% HAMA	25°C	1.3 bar	6.5 mm/s	11°C	-0.2		-0.7	

GelMA & 2% HAMA combination

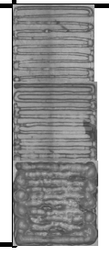
INPUT						OUTPUT			
Experiment Number	GelMA %	Temperature (ink)	Pressure	Speed	Temperature (platform)	Fibre formation		Layer Stacking	
1	7.5% GelMA, 2% HAMA	25°C	3.2 bar	9.5 mm/s	10°C	-0.3		-2	
2	7.5% GelMA, 2% HAMA	25°C	2.8 bar	5.0 mm/s	10°C	-0.2		-1	
3	7.5% GelMA, 2% HAMA	25°C	2.5 bar	11 mm/s	10°C	-0.1		-0.3	

Experiment Number : Eight

GelMA (filtered)

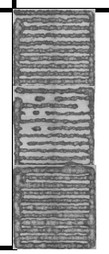
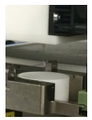
INPUT						OUTPUT			
Experiment Number	**GelMA %**	**Temperature (ink)**	**Pressure**	**Speed**	**Temperature (platform)**	**Fibre formation**		**Layer Stacking**	
1	5	15°C	0.6 bar	7.3 mm/s	25°C	0.2		2.2	 
2	5	15°C	1.7 bar	9.9 mm/s	25°C	-0.1		1.3	
3	5	15°C	0.8 bar	7.8 mm/s	25°C	0.2		1.8	

GelMA & 2% HAMA combination

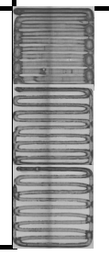
INPUT						OUTPUT			
Experiment Number	**GelMA %**	**Temperature (ink)**	**Pressure**	**Speed**	**Temperature (platform)**	**Fibre formation**		**Layer Stacking**	
1	7.5% GelMA, 2% HAMA	25°C	2.1 bar	12 mm/s	11°C	-0.1		-0.4	 
2	7.5% GelMA, 2% HAMA	25°C	2.5 bar	12 mm/s	11°C	-0.1		-0.2	
3	7.5% GelMA, 2% HAMA	25°C	3.4 bar	5 mm/s	11°C	-0.2		-2.2	

Experiment Number : Nine

GelMA (filtered)

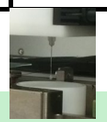
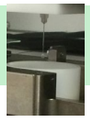
INPUT						OUTPUT			
Experiment Number	**GelMA %**	**Temperature (ink)**	**Pressure**	**Speed**	**Temperature (platform)**	**Fibre formation**		**Layer Stacking**	
1	5	15°C	4.0 bar	11.7 mm/s	10°C	-0.1		0.3	 
2	5	15°C	3.6 bar	11.8 mm/s	10°C	-0.15		0.35	
3	5	15°C	4.0 bar	10.4 mm/s	10°C	-0.1		0.29	

GelMA & 2% HAMA combination

INPUT						OUTPUT			
Experiment Number	**GelMA %**	**Temperature (ink)**	**Pressure**	**Speed**	**Temperature (platform)**	**Fibre formation**		**Layer Stacking**	
1	7.5% GelMA, 2% HAMA	25°C	2.3 bar	12.5 mm/s	10°C	-0.1		-0.25	 
2	7.5% GelMA, 2% HAMA	25°C	1.7 bar	15.0 mm/s	10°C	-0.1		-0.3	
3	7.5% GelMA, 2% HAMA	25°C	1.6 bar	9.0 mm/s	10°C	-0.1		-0.35	

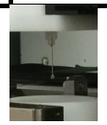
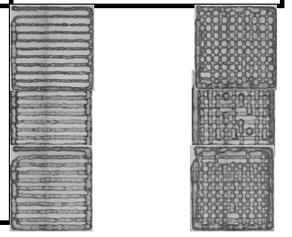
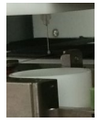
Experiment Number : Ten -Preparation of 5% GelMA & 7.5% GelMA:HAMA bioinks with GelMA batch 3 & HAMA batch 367, 5% Irgacure 1:25 dilution on 01-05-2020

GelMA & 2% HAMA combination

INPUT						OUTPUT			
Experiment Number	GelMA %	Temperature (ink)	Pressure	Speed	Temperature (platform)	Fibre formation		Layer Stacking	
1	7.5% GelMA, 2% HAMA	25°C	1.5 bar	12.0 mm/s	10°C	0		-0.35	
2	7.5% GelMA, 2% HAMA	25°C	1.4 bar	8.0 mm/s	10°C	0		0	TARGET
3	7.5% GelMA, 2% HAMA	25°C	1.2 bar	12.5 mm/s	10°C	didn't do			
4	7.5% GelMA, 2% HAMA	25°C	1.0 bar	16.5 mm/s	10°C	didn't do			

Experiment Number : Eleven

GelMA (filtered)

INPUT						OUTPUT			
Experiment Number	GelMA %	Temperature (ink)	Pressure	Speed	Temperature (platform)	Fibre formation		Layer Stacking	
1	5	20°C	0.9 bar	11.1 mm/s	11°C	-0.5		-0.1	
2	5	20°C	0.8 bar	9.2 mm/s	11°C	-0.5		-0.15	
3	5	20°C	1.2 bar	12.2 mm/s	11°C	-0.5		-0.2	

Experiment Number : Twelve

GelMA (filtered)

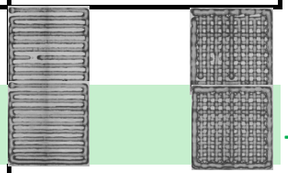
INPUT						OUTPUT				
Experiment Number	**GelMA %**	**Temperature (ink)**	**Pressure**	**Speed**	**Temperature (platform)**	**Fibre formation**		**Layer Stacking**		
1	5	18°C	0.5 bar	11.8 mm/s	10°C	0		-0.1		
2	5	18°C	0.5 bar	17.2 mm/s	10°C	0		0		**TARGET**
3	5	18°C	0.5 bar	5 mm/s	10°C	didn't do				

TABLE 1

Overall print score for ALL THREE Concentrations of GelMA bioink

Run No.	Expt No.	GelMA %	Ink Temp °C	Pressure (bar)	Speed mm/s	Plat Temp °C	Filament formation	Layer Stacking	**Print Score**
1	1	5	22	3	15	10	-2	-3	5
1	2	5	22	2.5	20	10	-1.5	-3	4.5
1	3	5	22	2	10	10	-1	-3	4
1	4	7.5	22	3	10	10	-1.9	-2.5	4.4
1	5	7.5	22	2.5	15	10	-1.9	-2.5	4.4
1	6	7.5	22	2	20	10	-1.9	-2.5	4.4
1	7	10	22	3	20	10	-0.5	-1	1.5
1	8	10	22	2.5	10	10	0	-0.3	0.3
1	9	10	22	2	15	10	-1	-0.7	1.7
2	10	10	25	2	10	10	-1.5	-1.1	2.6
2	11	10	25	2	12	10	-1.5	-1.3	2.8
2	12	10	25	2.9	10	10	-1.8	-1.9	3.7
2	13	10	25	2	20	10	-1.5	-1.2	2.7
2	14	10	25	2	14.5	10	-1.5	-1.6	3.1
2	15	10	25	2	17	10	-1.5	-1.7	3.2
2	16	10	25	3	12.5	10	-2	-2	4
2	17	10	25	3	20	10	-2	-2	4
3	18	10	22	2.4	10	10	0	-0.1	0.1
3	19	10	22	2.5	11	10	0	-0.1	0.1
3	20	10	22	2.6	10	10	0	-0.15	0.15
3	21	10	22	2.5	10.5	10	0	-0.1	0.1
3	22	10	22	2.4	10.5	10	0	-0.1	0.1
3	23	10	22	2.6	11	10	0	-0.15	0.15
3	24	10	22	2.3	10	10	0	-0.1	0.1
3	**25**	**10**	**22**	**2.4**	**11.5**	**10**	**0**	**0**	**0**
3	26	10	22	2.6	10.5	10	0	-0.15	0.15
3	27	10	22	2.5	11.5	10	0	-0.1	0.1
4	28	5	21	2	10	10	-0.9	-2	2.9

Run No.	Expt No.	GelMA %	Ink Temp °C	Pressure (bar)	Speed mm/s	Plat Temp °C	Filament formation	Layer Stacking	**Print Score**
4	29	5	21	2	13	10	-0.9	-2	2.9
4	30	5	21	2.2	10	10	-1	-2	3
4	31	5	21	2.3	13.5	10	-1.2	-2	3.2
4	32	5	21	2	11	10	-0.9	-2	2.9
4	33	5	21	2.1	10.5	10	-1	-2	3
4	34	5	21	2.1	12	10	-1	-2	3
4	35	5	21	2.2	11	10	-1	-2	3
4	36	5	21	2	10.5	10	-0.9	-2	2.9
4	37	5	21	2.1	10	10	-1	-2	3
4	38	7.5	20	2	15.5	10	0	0	0
4	39	7.5	20	2.5	10	10	-0.1	-0.2	0.3
4	40	7.5	20	2.5	18	10	-0.1	-0.1	0.2
4	41	7.5	20	3	10	10	-0.15	-1	1.15
4	42	7.5	20	2	20	10	0	0.2	0.2
4	43	7.5	20	2.5	14.5	10	-0.1	-0.5	0.6
4	44	7.5	20	2.1	13	10	0	0.1	0.1
4	45	7.5	20	2.2	16	10	0	0	0
4	46	7.5	20	2	17.5	10	0	-0.1	0.1
4	47	7.5	20	2.1	14.5	10	0	-0.1	0.1
5	48	5	20	1	10	10	-0.5	-0.2	0.7
5	49	5	20	3.4	10	10	-1.2	-2	3.2
5	50	5	20	1	12.5	10	-0.5	-0.4	0.9
5	51	5	20	1.4	10	10	-1	-1	2
5	52	5	16	3.8	11	10	0.5	0.2	0.7
5	53	5	15	1	8	25	-0.2	-0.1	0.3
5	54	5	15	4	20	25	0	-0.9	0.9
5	55	5	15	1	20	25	-0.2	-0.5	0.7
5	56	5	15	3.9	8	25	0	-1	1
5	57	5	15	2.5	14	25	-0.1	-0.6	0.7
6	68	5	21	1	10.5	10	-0.6	-1.8	2.4
6	69	5	21	1	8.5	10	-0.6	-2	2.6

Run No.	Expt No.	GelMA %	Ink Temp °C	Pressure (bar)	Speed mm/s	Plat Temp °C	Filament formation	Layer Stacking	**Print Score**
6	70	5	21	1	12	10	-0.6	-1.5	2.1
6	71	5	21	1.2	10.5	10	-0.8	-2	2.8
6	72	5	21	1	9.5	10	-0.6	-2	2.6
6	73	5	15	1.3	9	25	-0.2	-0.2	0.4
6	74	5	15	1	9.5	25	-0.2	-0.8	1
6	75	5	15	2.3	12.5	25	-0.2	-1	1.2
6	76	5	15	1.2	8	25	-0.2	-0.4	0.6
6	77	5	15	1.1	8.5	25	-0.2	-0.2	0.4
7	88	5	19	0.8	10.6	10	0.1	2	2.1
7	89	5	19	0.7	9.4	10	0.1	2	2.1
7	90	5	19	1	10.7	10	0.1	1.7	1.8
8	94	5	15	0.6	7.3	25	0.2	2.2	2.4
8	95	5	15	1.7	9.9	25	-0.1	1.3	1.4
8	96	5	15	0.8	7.8	25	0.2	1.8	2
9	97	5	15	4	11.7	10	-0.1	0.3	0.4
9	98	5	15	3.6	11.8	10	-0.15	0.35	0.5
9	99	5	15	4	10.4	10	-0.1	0.29	0.39
11	100	5	20	0.9	11.1	11	-0.5	-0.1	0.6
11	101	5	20	0.8	9.2	11	-0.5	-0.15	0.65
11	102	5	20	1.2	12.2	11	-0.5	-0.2	0.7
12	103	5	18	0.5	11.8	10	0	-0.1	0.1
12	104	5	18	0.5	17.2	10	0	0	0

TABLE 2

Overall print score for ALL THREE Concentrations of GelMA: HAMA bioink combination

Run No.	Expt No.	GelMA % 2% HAMA	Ink Temp °C	Pressure (bar)	Speed mm/s	Plat Temp °C	Filament formation	Layer Stacking	**Print Score**
1	1	10	25	3.5	10	10	-0.1	-1.8	1.9
1	2	10	25	3	8.5	10	-0.1	-1.5	1.6
1	3	10	25	2.5	10	10	0	-0.4	0.4
1	4	7.5	25	3.5	18	10	-0.2	-2.7	2.9
1	5	7.5	25	3	18	10	-0.2	-2.5	2.7
1	6	7.5	25	2.5	8	10	-0.2	-2.4	2.6
1	7	5	25	3.5	8	10	-0.3	-2.8	3.1
1	8	5	25	3	10	10	-0.3	-2.5	2.8
1	9	5	25	2.5	8	10	-0.3	-2.4	2.7
2	10	10	29	2.5	11.5	10	-0.6	-2.8	3.4
2	11	10	29	2.5	8	10	-0.6	-2.9	3.5
2	12	10	29	2.5	14	10	-0.6	-2.8	3.4
2	13	5	29	2.5	13.5	10	-0.4	-2.6	3
2	14	10	29	2.5	18	10	-0.6	-2.7	3.3
2	15	5	29	2.5	18	10	-0.4	-2.6	3
2	16	10	29	2.5	10	10	-0.6	-2.8	3.4
2	17	5	29	2.5	10.5	10	-0.4	-2.6	3
3	18	10	25	2.5	11	10	-0.1	-0.5	0.6
3	19	10	25	2.6	10	10	-0.1	-0.8	0.9
3	20	10	25	2.5	10.5	10	-0.1	-0.6	0.7
3	21	10	25	2.6	11	10	-0.1	-0.6	0.7
3	22	10	25	2.6	8.5	10	-0.1	-0.8	0.9
3	23	10	25	2.5	9.5	10	-0.1	-0.7	0.8
3	24	10	25	2.6	10.5	10	-0.1	-0.7	0.8

Run No.	Expt No.	GelMA % 2% HAMA	Ink Temp °C	Pressure (bar)	Speed mm/s	Plat Temp °C	Filament formation	Layer Stacking	**Print Score**
3	25	10	25	2.6	9.5	10	-0.1	-0.7	0.8
3	26	10	25	2.5	11.5	10	-0.1	-0.45	0.55
3	27	10	25	2.5	9	10	-0.1	-0.5	0.6
4	28	10	25	2.5	8.5	10	-0.1	-0.4	0.5
4	29	10	25	2.6	9	10	-0.1	-0.7	0.8
4	30	10	25	2.5	12	10	-0.1	-0.6	0.7
4	31	10	25	2.6	11.5	10	-0.1	-0.7	0.8
4	32	10	25	2.6	8	10	-0.1	-0.7	0.8
4	33	10	25	2.5	8	10	-0.1	-0.7	0.8
4	34	10	25	3	8	10	-0.1	-0.8	0.9
4	35	10	25	3	9	10	-0.1	-0.8	0.9
4	36	10	25	2.5	12.5	10	-0.1	-0.6	0.7
4	37	10	25	2.6	12	10	-0.1	-0.6	0.7
4	38	5	25	2.7	13	10	-0.3	-2.8	3.1
4	39	5	25	3.3	13	10	-0.4	-2.9	3.3
4	40	7.5	25	2.7	16.5	10	-0.3	-2.7	3
4	41	5	25	2.6	10.5	10	-0.3	-2.9	3.2
4	42	5	25	2.5	12	10	-0.3	-2.8	3.1
4	43	5	25	2.5	13.5	10	-0.3	-2.8	3.1
4	44	5	25	2.5	9.5	10	-0.3	-2.9	3.2
4	45	5	25	2.6	8.5	10	-0.3	-2.9	3.2
4	46	5	25	2.5	10.5	10	-0.3	-2.8	3.1
4	47	5	25	2.5	9	10	-0.3	-2.8	3.1
5	48	10	25	2.9	9.5	10	0	-0.4	0.4
5	49	10	25	3.1	9.5	10	0	-0.8	0.8
5	50	10	25	2.4	10	10	0	-0.5	0.5
5	**51**	**10**	**25**	**2.6**	**12.5**	**10**	**0**	**0**	**0**
5	52	10	25	1.5	8.5	10	1	1	2
5	53	10	15	1	8	25	3	3	6
5	54	10	15	1	12	25	3	3	6

Run No.	Expt No.	GelMA % 2% HAMA	Ink Temp °C	Pressure (bar)	Speed mm/s	Plat Temp °C	Filament formation	Layer Stacking	**Print Score**
5	55	10	15	1	15	25	3	3	6
5	56	10	15	1	17.5	25	3	3	6
5	57	10	15	1	10	25	3	3	6
5	58	5	15	1	8	10	2.8	2.7	5.5
5	59	5	15	1	12	10	2.8	2.7	5.5
5	60	5	15	1	15	10	2.8	2.8	5.6
5	61	5	15	1	17.5	10	2.8	2.9	5.7
5	62	5	15	1	10	10	2.8	2.7	5.5
5	63	5	15	1	8	25	2.8	2.5	5.3
5	64	5	15	1	12	25	2.8	2.5	5.3
5	65	5	15	1	15	25	2.8	2.5	5.3
5	66	5	15	1	17.5	25	2.8	2.5	5.3
5	67	5	15	1	10	25	2.8	2.5	5.3
6	68	7.5	15	1	8	10	3	3	6
6	69	7.5	15	1	12	10	3	3	6
6	70	7.5	15	1	15	10	3	3	6
6	71	7.5	15	1	17.5	10	3	3	6
6	72	7.5	15	1	10	10	3	3	6
6	73	7.5	15	1	8	25	3	3	6
6	74	7.5	15	1	12	25	3	3	6
6	75	7.5	15	1	15	25	3	3	6
6	76	7.5	15	1	17.5	25	3	3	6
6	77	7.5	15	1	10	25	3	3	6

Run No.	Expt No.	GelMA % 2% HAMA	Ink Temp °C	Pressure (bar)	Speed mm/s	Plat Temp °C	Filament formation	Layer Stacking	**Print Score**
6	78	5	25	2.2	8	11	-0.2	-1.8	2
6	79	5	25	1.3	8	11	-0.15	-0.5	0.65
6	80	5	25	1.8	8	11	-0.2	-1.5	1.7
6	81	5	25	2	9	11	-0.2	-1.7	1.9
6	82	5	25	1.6	9.5	11	-0.1	-1.5	1.6
7	83	5	25	1.3	8	11	-0.2	-0.5	0.7
7	84	5	25	1	9	11	0	0	0
7	85	5	25	1.3	6.5	11	-0.2	-0.7	0.9
7	86	7.5	25	3.2	9.5	10	-0.3	-2	2.3
7	87	7.5	25	2.8	5	10	-0.2	-1	1.2
7	88	7.5	25	2.5	11	10	-0.1	-0.3	0.4
8	89	7.5	25	2.1	12	11	-0.1	-0.4	0.5
8	90	7.5	25	2.5	12	11	-0.1	-0.2	0.3
8	91	7.5	25	3.4	5	11	-0.2	-2.2	2.4
9	92	7.5	25	2.3	12.5	10	-0.1	-0.25	0.35
9	93	7.5	25	1.7	15	10	-0.1	-0.3	0.4
9	94	7.5	25	1.6	9	10	-0.1	-0.35	0.45
10	95	7.5	25	1.5	12	10	0	-0.35	0.35
10	96	7.5	25	1.4	8	10	0	0	0