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SAMPLE LANDSCAPE STUDY – 3D Printing Plastic Materials



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1. INTRODUCTION

1.1. 3D Printing Plastic Materials

Plastics have been the most associated materials with the field of 3D printing or additive manufacturing for long time and majority of today's consumer products and commercial ones are composed of thermoplastics. 3D printing with plastics allows for the quick creation of quality prototypes with recent advances in printing materials and technology.

The most commonly used thermoplastics in 3D printing are ABS, polycarbonate, polyamides, polylactic acid (PLA), polycarbonates, polyolefins, thermoplastic polyurethane (TPU), photopolymers, etc.

The engineered thermoplastics in 3D printing can be used for aerospace, medical devices & implants, automotive, electronics and other specialty applications. The application and requirement will determine the plastic material and technology to be used in 3D printing materials.

Recently, a number of plastic-based materials have been introduced that incorporate metallic elements, allowing objects to printed with some of the qualities of metal parts without the added complexity of 3D printing with metal. The most popular 3D printing manufacturing technologies to date are Stereolithography (SL), Laser Sintering (LS), Fused Deposition Modeling (FDM), Direct Metal Laser Sintering (DMLS), and Digital Laser Projection (DLP).

1.2 Growth Prospects of 3D Printing Plastic Materials

The global 3D printing plastics materials market size is estimated to be at USD 1965 million by 2023 at a rate of CAGR of 26.1%. 3D printing technology is highly efficient thereby reducing time, effort and cost when compared with traditional manufacturing methods which helps to widen the 3D printing applications in different industries like manufacturing shoes, musical instruments, building parts, car components, dental, jewellery, functional ceramics, robots, prosthetics, and casts.

Furthermore, with the decreasing prices of printers as well as technological advancements pertaining to the printers, the market for the 3D printing plastics is expected to grow at an extremely high rate. Major manufacturing companies, aerospace and defense industries, and few healthcare companies located in the U.S have already started using 3d printing in a wide range of For sources of information, please refer to Appendix A



applications using various types of plasticbased materials.

It is a critical time to understand the global competitive environment of 3d printing technology from a patent perspective and indepth patent analysis of key technologies and players can help anticipate changes, detect business opportunities, mitigate risks and make strategic decisions to strengthen one's market position and maximize return on one's IP portfolio. Some of the prominent participants in the global market of producing 3D printing plastics are Lotte Chemicals, HP Inc., Sabic Technologies, Evonik Industries, Arkema, Stratasys Ltd, Carbon 3d Inc., BASF, and EOS.

For sources of information, please refer to Appendix A



2. OBJECTIVES

- To perform detailed analysis of granted patents and published applications pertaining to 3D printing plastic materials and to understand underlying technologies.
- In depth analysis of patents/applications, in order to categorize them and to understand focusing areas of applicants.
- Graphical representation of trends (Filing, Publication, etc.) from the mined data of relevant patents/applications.



Image Courtesy

2.1 SEARCH METHODOLOGY



Image Courtesy

The first step is to create and define a patent set that will serve as the basis of analysis. Using renowned patent database, Derwent Innovation as our data source, we extracted data set of patents/published applications filed during the last ten years (2010-2019) by performing search in Abstract, Title, and Claims fields using keywords and International Patent Classifications.

3.1 PRIORITY, FILING, PUBLICATION YEAR BASED TREND ANALYSIS

3.1.1 ANALYSIS BASED ON REPRESENTATIVE MEMBER PER INPADOC FAMILY

Below graph represents application year and publication year trends for the patent publications pertaining to 3D printing plastic materials technology.



Note: Attributed to non-published patent applications, there may be a higher count in the years 2018-2019.

INSIGHT:

- Filing year trend provides insights for the number of applications filed during the period 2010-2019. As depicted in the graph, there is a gradual rise in patent applications filing over the years, wherein maximum numbers of patent applications were filed in the year 2016.
- Publication trend provides insights for the number of applications published during the period 2010-2019. As indicated in the graph, there is a gradual rise in publication over the years, wherein maximum numbers of patent applications were published in the year 2018 indicating significant filing during 2016-2017.



3.2 ASSIGNEE BASED TREND ANALYSIS

3.2.1 MAJOR ASSIGNEES (BASED ON REPRESENTATIVE MEMBER PER FAMILY)

The below graph represents major assignees in the domain.



INSIGHT:

As evident from the chart herein above, Heilongjiang Xinda Enterprise Group Co. Ltd. leads the pack with 11 patent families followed by Lotte Chemical Corportation (10 patent families) and Institute of Chemistry CAS (9 patent families).

THE TOP ASSIGNEES ARE:

- HEILONGJIANG XINDA ENTPR GROUP CO LTD
- LOTTE CHEMICAL CORP
- INSTITUTIE OF CHEMISTRY, CHINESE ACADEMY OF SCIENCE
- HP
- MENG YU

- ✤ SABIC GLOBAL TECHNOLOGIES
- GUANGXI FENGDA 3D TECH CO LTD
- STRATASYS
- LUBRIZOL ADVANCED MATERIALS INC
- ✤ KOLON PLASTICS INC



3.3 KEY INVENTORS



The below graph names the inventors with most number of innovations on their name.

INSIGHT:

The chart demonstrates top inventors, wherein '**Dong**, **Jin-Yong**' with 10 patent families emerged out as leading inventor followed by '**Li, Chun-Cheng'** & '**Fu, Wen-Xin'** with 9 patent families each in 3D printing plastic materials technology domain.



3.4 GEOGRAPHY BASED TREND ANALYSIS

3.4.1 GEOGRAPHICAL DISTRIBUTION OF PATENT APPLICATION FILINGS

Priortiy Year \longrightarrow Priority Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Grand Total
CN		1			2	12	10	32	20	11	1	89
US		2			1	2	2	9	11	17		44
KR						5	6	10	9	2		32
EP							1		3	5		9
wo							2		3	1		6
RU							2	2	1			5
DE						1				3		4
JP								1	1		1	3
DK								1		1		2
Others								2	1	5		8
Grand Total		3			3	20	23	57	49	45	2	202

INSIGHT:

Trend related to Geographical filing demonstrates that the maximum number of filings originated from CN followed by US & KR jurisdictions.



3.5 INTERNATIONAL PATENT CLASSIFICATION BASED TREND

C08G C09D D01F **C08F** C08L C04B 4% 1% 2% 3% 29% 1% G03F 1% G03G 0% D01F 1% C08J 2% G03F 1% A61L 2% C08K others B29B 27% **B33Y** B29C 4% 2% 11% 11%

The below graph represents frequently assigned international patent classes.

INSIGHT:

Majority of patent applications were assigned with IPC "**Co8L**" related to 'Compositions of Macromolecular Compounds' followed by "**Co8K**" related to 'Use of Inorganic or Non-Macromolecular Organic Substances As Compounding Ingredients (paints, inks, varnishes, dyes, polishes, adhesives' and "**B33Y**" related to 'Additive Manufacturing, i.e. Manufacturing of Three-Dimensional [3d] Objects By Additive deposition, Additive Agglomeration or Additive Layering, e.g. By 3d Printing, Stereolithography or Selective Laser Sintering'.



3.6 INTERNATIONAL PATENT SUB-CLASSIFICATION BASED TREND

The below graph represents sub-classes pertaining to one of the top/main patent classes.



Co8K Sub-classification

Co8L Sub-classification





3.1 KEY TECHNOLOGICAL TRENDS

3.1.1 TAXONOMY DEVELOPED FOR BUCKETING OF RELEVANT PATENT DOCUMENTS

A set of 202 patent families were analyzed in depth to identify the focus areas of the patents related to the domain of 3D printing plastic materials





3.1.2 DISTRIBUTION OF PATENTS/APPLICATIONS PERTAINING TO 3D PRINTING PLASTIC MATERIALS



Below representation shows the dissection in terms of type of polymer used for 3d printing.

INSIGHT:

As evident from the graph, 31% of patents/applications focused on Polylactic acid based materials used in 3D printing technology followed by Polyolefin (17%) and Acrylonitrile Butadiene Styrene (11%).



3.1.3 DISTRIBUTION OF PATENTS/APPLICATIONS PERTAINING TO FORM OF MATERIAL OF 3D PRINTING PLASTIC MATERIASL

This category deals with patents/applications pertaining to the dissection of form of polymer material used for 3D printing.



INSIGHT:

As evident from the graph, 43% of patent filings disclosed powder form of polymer based materials used for 3D printing while 41% of patent filings disclosed filament form and 16% of patent filings disclosed liquid form of materials.



3.1.4 DISTRIBUTION OF PATENTS/APPLICATIONS BASED ON 3D PRINTING TECHNOLOGY

Below representation shows dissection of 3D printing technology wherein the plastic materials can be used.



INSIGHT:

As evident from the graph, 23% of patent filings focused on usage of polymeric plastic materials in fused deposition modeling 3D printing technology while 12% patent filings disclosed selective laser sintering method of 3D printing.



4. Patent Portfolio Analysis

4.1 Patent Portfolio Analysis - Heilongjiang Xinda Enterprise Group Co Ltd

Company Profile

Heilongjiang Xinda is a China based company focusing on the R&D, manufacturer and distribution of plastic composites with application in the areas of automobile, high speed train, ship, aerospace etc.



Polymer Dissection

Form of Material Dissection





For sources of information, please refer to Appendix A



Key Patents – Heilongjiang Xinda Enterprise Group Co Ltd



Patent No.	Key Features
	The present document relates to a <u>polylactic acid (PLA) composite powder</u>
	material for the field of application of print material which can be used in <u>fused</u>
<u>CN106700358A</u>	deposition modelling (FDM) of 3d printing technology. The materials have
	advantages of water solubility and biodegradability so that the environment-
	friendly characteristic of the material is guaranteed.
	The patent document relates to an <u>environment-friendly polybutylene succinate</u>
	(PBS) based 3d printing plastic composite material. The material is in powder
<u>CN108070230A</u>	form and uses for any type of 3d printing technology and provides diverse
	environmental protection materials for 3d printing
	The patent document discloses a <u>powdered nylon 12 material for the field of 3d</u>
	printing and its preparation method. The invention also discloses that the
<u>CN107151441A</u>	material particularly useful for selective laser sintering technology of 3d printing.
	The material is cost effective whle the mechanical properties are significantly
	improved.



4.2 Patent Portfolio Analysis – Lotte Chemical Corporation

LOTTE CHEMICAL

Company Profile

Lotte Chemical is a Korean based company manufacturing and selling polymers including thermoplastic elastomers, adhesive resins, thermoplastic olefins, long fiber reinforced thermoplastics, and expanded polypropylenes, high density, low-density polyethylene, as well as ethylene-vinyl acetate; transparent-impact resistance polypropylene, as well as polypropylene for injection and blow molding, yarns/fibers, and films.



Polymer Dissection





3D Printing Technology Dissection



For sources of information, please refer to Appendix A



Key Patents – Lotte Chemical Corporation LOTTE CHEMICAL

Patent No.	Key Features			
<u>US10214658B2</u>	The patent document relates to a thermoplastic resin composition with low			
	hardness and more <u>soft feeling for three-dimensional printer filaments</u> . <u>The</u>			
	thermoplastic polymer used in the resin composition is polypropylene having a			
	weight average molecular weight of 50,000 to 1,000,000, a density of 0.8 to 0.9			
	g/ml, and isotacticity of 5 to 20%, wherein a melting index (210° C., 2.16 kg) of			
	the polymer base is 0.5-30 g/10 minutes. The filament polymer material can be			
	used in any type of 3d printing technology.			
	The patent document relates to polylactic acid composition filament for 3d			
	printing materials. The present invention relates to a three-dimensional printer-			
<u>KR1711279B1</u>	filament polylactic acid composition of poly-L- lactic acid resin, 50 to 95% by			
	weight and poly D- lactic acid resin, 5 to 50% by weight; and used in any type of			
	3d printing technology.			



4.3 Patent Portfolio Analysis – Hewlett-Packard Development Company, L.P

Company Profile

Hewlett-Packard Development Company, L.P. is subsidiary of HP Inc. and provides large-format, commercial and industrial printing solutions. Additionally the company manufactures computer hardware and develops software.



Polymer Dissection

For sources of information, please refer to Appendix A

(III)



Key Patents – Hewlett-Packard Development Company, L.P

Patent No.	Key Features
	The patent relates to <u>a thermoplastic polymer</u> composition <u>for three-dimensional</u>
	(3d) printing. The composition is in liquid form and will be used in digital light
<u>US10280299B2</u>	projection 3d printing technology. Polyolefins, polycarbonates and ABS are the
	thermoplastic polymer used in the invention.
	The patent document relates to a three-dimensional printing material
	composition includes a polymer particle, and a radiation absorbing additive
	mixed with the polymer particle. The composition is in the powder form and can
	be used in the selective laser sintering 3d printing technology. The polymer can
	be used in the invention are <u>polyamides, polyethylene, polyethylene</u>
<u>US20180126631A1</u>	terephthalate (PET), polystyrene (PS), polyacetals, polypropylene, polycarbonate
	(PC), polyester, polyoxymethylene (POM), polyether ether ketone (PEEK),
	polyetherketoneketone (PEKK), polyphenylene sulfide (PPS),
	polytetrafluoroethylene (PTFE), polyvinylidene fluoride (PVDF), acrylonitrile
	styrene acrylate (ASA), poly(methyl methacrylate) (PMMA), styrene acrylonitrile
	(SAN), styrene maleic anhydride (SMA), poly(vinyl chloride) (PVC),
	polyethylenimine (PEI).



(hp

5. Analysis of Key Granted Patents/Patent Applications Assigned to Educational Institutes and Other Companies

5.1 Granted Patents/Patent Applications – Institute of Chemistry CAS

Patent No.	Key Features
<u>US20170253702A1</u>	This patent document relates to a high molecular weight <u>nylon powder</u> <u>composition for 3d printing materials</u> and its preparation method. The powder composite material particularly developed to use <u>selective laser sintering 3d</u> <u>printing technology</u> . The high molecular weight nylon powder composition has good mechanical properties, good dimensional stability and low manufacturing cost.
<u>CN104031304B</u>	The patent document relates to a printing <u>UV cross-linked polymer based</u> <u>composite material for 3d printing</u> . The material is in filament form and can be used in any type of 3d printing technology. Wherein said polymer resin is a linear thermoplastic resin selected from <u>polyolefins</u> , <u>polyamides</u> , <u>polycarbonates</u> , <u>polyoxymethylene</u> , <u>polyester</u> , <u>acrylonitrile</u> - <u>styrene</u> - <u>butadiene</u> <u>copolymer</u> , <u>a styrene - butadiene - styrene block copolymer</u> , <u>styrene - isoprene -</u> <u>styrene block copolymer</u> and at least one transparent impact butadiene-styrene resin.
<u>CN104031262B</u>	The patent document relates to a <u>nylon polymer for 3d printing</u> wherein the material is in <u>powder form and can be used in selective laser sintering 3d</u> <u>printing technology</u> . Nylon powder of the present invention has a viscosity-average molecular weight of 5 to 900,000 adjustable, powder particle size 20 to 100 microns controllable.



5.2 Granted Patents/Patent Applications – Other Companies

Patent No.	Key Features
US20190177473A1 Sabic Global Technologies	The patent document relates to a <u>powdered polymer composition for</u> <u>production of 3d printing</u> objects via <u>selective laser sintering</u> method wherein the polymer composition comprises a thermoplastic polyester polymer. The thermoplastic material is a <u>polyester selected from</u> <u>poly(ethylene terephthalate)</u> , poly(ethylene naphthalate), poly(ethylene furanoate), poly(trimethylene terephthalate), poly(ethylene succinate), <u>or poly(hydroxyl butyrate)</u> .
US20180282471A1 Lubrizol Advanced Materials Inc.	The patent document relates to a <u>powdered composition for 3d printing</u> fabrication of medical devices, components and applications in which the composition includes a <u>thermoplastic polyurethane</u> which is particularly suited for such processing. The useful thermoplastic polyurethanes are derived from a polyisocyanate component including a first linear aliphatic diisocyanate and a second aliphatic diisocyanate, a polyol component, and (c) a chain extender component. The <u>material can be used fused</u> <u>deposition modelling & selective laser sintering of 3d printing technology</u> .
KR2018001191A Kolon Plastics Inc.	The patent document relates to a <u>filament composition for three- dimensional printing materials</u> manufactured by extruding the filament composition through three-dimensional printing. The filament composition of the present invention comprises one or more of biocompatible polymers selected from the group consisting of <u>poly L- lactic acid (PLA), polyglycolic acid (PGA), poly D,L-lactide-co-glycolide</u> (PLGA), polycaprolactone (PCL), polyvalerolactone (PVL), polyhydroxybutyrate (PHB), and polyhydroxyvalerate (PHV) to manufacture a three-dimensional molded objects



6. Appendix A : Sources

- An Introduction to 3d Printing with Plastics
- 3d PRINTING MATERIALS: CHOOSING THE RIGHT MATERIAL FOR YOUR APPLICATION
- <u>Thermoplastics: The Strongest Choice for 3d Printing</u>
- Materials for 3d Printing by Fused Deposition
- <u>A Comprehensive Study on 3d Printing Technology</u>
- <u>https://www.grandviewresearch.com/industry-analysis/3d-printing-plastics-market</u>
- https://make.3dexperience.3ds.com/materials/plastic-materials-for-3d-printing-processes
- <u>https://www.prnewswire.com/news-releases/global-3d-printing-plastics-market-is-anticipated-to-grow-at-a-cagr-of-20-5-during-2018-2023--300704097.html</u>
- https://www.globenewswire.com/news-release/2019/02/14/1725665/0/en/3d-Printing-Plastics-Market-Global-Forecast-to-2023-Market-is-Estimated-at-USD-615-8-Million-in-2018and-is-Projected-to-Reach-USD-1-965-3-Million-by-2023.html
- https://www.lottechem.com/kor/main/index.do
- https://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapId=24054431
- <u>https://www.bloomberg.com/profile/company/1048281D:CH</u>
- <u>https://www.listcompany.org/Heilongjiang_Xinda_Enterprise_Group_Co_Ltd_Info.html</u>



6.1 Appendix B : IPC Definitions

IPC	Definition
Co8K	USE OF INORGANIC OR NON-MACROMOLECULAR ORGANIC SUBSTANCES AS COMPOUNDING INGREDIENTS (paints, inks, varnishes, dyes, polishes, adhesives Co9)
C08K 13/02	Organic and inorganic ingredients
C08K 3/00	Use of inorganic substances as compounding ingredients
Co8K 3/22	of metals
Co8K 3/26	Carbonates; Bicarbonates
Co8K 03/34	Silicon-containing compounds
Co8L	COMPOSITIONS OF MACROMOLECULAR COMPOUNDS (compositions based on polymerisable monomers Co8F, Co8G; artificial filaments or fibres Do1F; textile treating compositions Do6)
Co8L 67/04	Polyesters derived from hydroxy carboxylic acids, e.g. lactones (Co8L 67/06 takes precedence)
Co8L 97/02	Lignocellulosic material, e.g. wood, straw or bagasse
Co8L 67/02	Polyesters derived from dicarboxylic acids and dihydroxy compounds (Co8L 67/06 takes precedence)
C08L 23/06	Polyethene
B33Y	ADDITIVE MANUFACTURING, i.e. MANUFACTURING OF THREE-DIMENSIONAL [3d] OBJECTS BY ADDITIVE DEPOSITION, ADDITIVE AGGLOMERATION OR ADDITIVE LAYERING, e.g. BY 3d PRINTING, STEREOLITHOGRAPHY OR SELECTIVE LASER SINTERING
B29C	SHAPING OR JOINING OF PLASTICS; SHAPING OF MATERIAL IN A PLASTIC STATE, NOT OTHERWISE PROVIDED FOR; AFTER-TREATMENT OF THE SHAPED PRODUCTS, e.g. REPAIRING (making preforms B29B 11/00; making laminated products by combining previously unconnected layers which become one product whose layers will remain together B32B 37/00-B32B 41/00)
Co8G	MACROMOLECULAR COMPOUNDS OBTAINED OTHERWISE THAN BY REACTIONS ONLY INVOLVING CARBON-TO-CARBON UNSATURATED BONDS (fermentation or enzyme- using processes to synthesise a desired chemical compound or composition or to separate optical isomers from a racemic mixture C12P)





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