Special Report (sample)

Technology Assessment - Sustainable Adhesives

INTRODUCTION

Like any other industry, adhesives are too impacted from the regulations and customer expectations driven by the sustainability movement. This impact has eventually got reflected in terms of seeking alternative feedstocks, improved manufacturing processes, and shift towards greener adhesive technologies.

About this report:

- This report captures latest developments in the field of sustainable adhesives with a focus on alternative feedstocks and greener adhesive technologies. Alternative feedstocks can be sustainable substitutes of traditional raw materials, used either in full or part, in the adhesive compositions. **Natural biopolymers, renewable monomers and renewable additives** represent the key feedstock materials covered in this report. For each material type, significant adhesive features, approaches to enhance performance, recent commercial and patent activities have been captured.
- Apart from feedstocks, activity of the major adhesive manufacturers, potential collaboration partners in the value chain, R&D trends and relevant patents have also been covered. Attaining sustainability through lower process emissions or recycling of synthetic polymers are excluded from the scope of this report.

Relevant audience:

- ✓ Adhesive manufacturers interested in exploring recent developments and potential collaborations within the value chain.
- ✓ Players in the packaging value chain and consumer goods manufacturers.
- ✓ Other companies already present or willing to enter in the domain.

Customization:

- Report contents can be customized based on user requirements. Accordingly, report coverage shall be reduced or expanded to the specific areas of interest.

CONTENTS

REPORT OVERVIEW

Captures approaches to enhance sustainability footprint of adhesive systems through alternative feedstocks

Holistic assessment of chemistries and technologies in terms of R&D activities, commercial activities, IP and joint collaborations.

Technology developers involved in the raw material as well as final adhesive formulation development

Structured assessment of each feedstock alternative based on Aranca Technology Assessment Framework

Information covered in the report

Chemistry Information

- Major chemistries under different sustainability enhancement options
- Performance properties, advantages and challenges, recent R&D developments
- Commercial activities and major players in value chain

Effect on Adhesive Technology

- Major technologies like and HMAs and PSAs
- Updates on potential bio-alternatives to the conventional synthetic ones
- Active players and research activity

Market and Value Chain

- Recent trends of bio-adhesives on adhesive market
- Value chain analysis
- Top player profiles

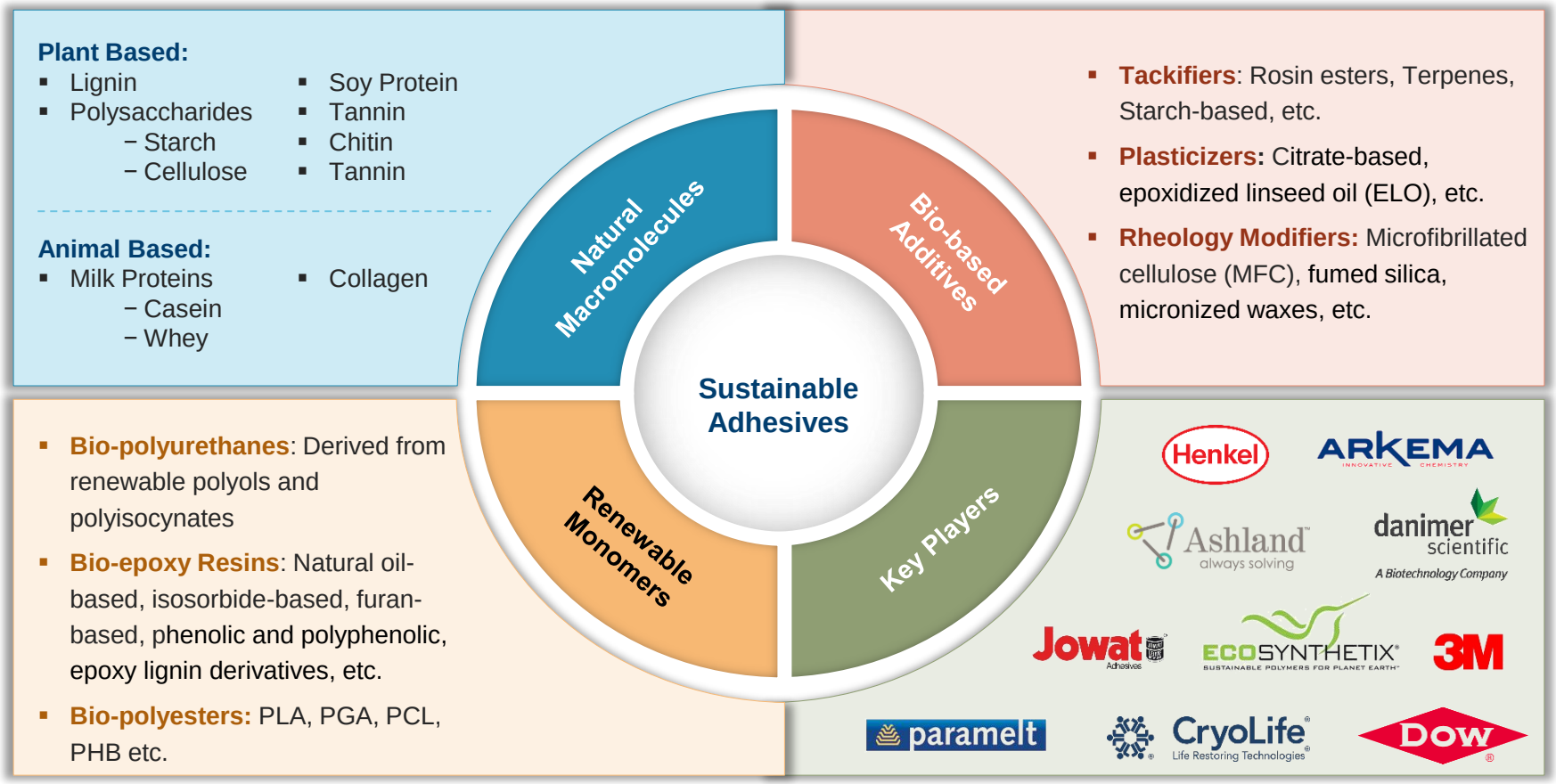
Patent Information

- Patent filing trend of for last 5 years (Publication year 2015 onwards)
- Geographical research activity
- Active assignee analysis.

TABLE OF CONTENTS

REPORT HIGHLIGHTS

Sustainable adhesives: Key aspects covered in the report



RESEARCH METHODOLOGY

Methodology

- The report mainly covers sustainable adhesive feedstocks and technologies. Attaining sustainability through lower emissions or recycling of synthetic polymers have not been considered.
- Major bio-based feedstock chemistries (polymeric and additives) have been analyzed and incorporated in the report (refer ToC, slide #4).
- The report focuses only on relevant adhesive technologies like HMAs and PSAs which are compatible with sustainable/bio-based chemistries in their formulations.
- Patent analysis was conducted mainly on keyword basis considering five-year duration (2015 onwards). Special focus has been given to the recent filings by the major market players.

Information Sources

Following paid and public sources of information were referred:

- Patent databases such as Questel Orbit
- Market databases such as EMIS, Euromonitor, Factiva and Bloomberg
- Scientific literature published on databases such as ScienceDirect, ResearchGate, Scopus, SpringerLink and Wiley Online
- Company websites, product brochures and news/media sections
- Industry associations and Government sources such as Adhesive and Sealant Council (ASC) and Society for Adhesion and Adhesives
- Specific publications/magazines on adhesives and bio-polymers like Adhesive and Sealant Magazine
- Aranca internal knowledge bases and industry experts

ARANCA TECHNOLOGY ASSESSMENT FRAMEWORK

Factor	Parameter	Score (1−5); higher is better					Min	Max
Technology	TRL						2	10
	Renewable Contents							
Patents	No of Patents Published(last 5yrs)						2	10
	Patent Status							
Collaborations	No of Industrial Collaborations						1	5
Applications	Target Adhesive Applications						1	5

Notes: *Total score is obtained by adding the individual factor scores.*

CONTENTS

SAMPLE REPORT CONTENTS

Key Observations

Chemistry

Adhesive Chemistries

- Recent advancements focus on complete or partial replacement of petroleum-based polymers with biopolymers.
- Highly functional polymers are developed from renewable monomers derived from vegetable oils.
- (…)

Technology

Adhesive Technologies in focus

- Hot-melt adhesives (HMAs) represent the most relevant and potential adhesive technology due to their widespread applicability in the environment-sensitive commercial applications like packaging.
- Alternatives to each synthetic HMA component are present in the market. Bio-polymers (soy proteins, starch esters, polylactide, polyamide, etc.), tackifiers (such as pine rosin, terpene and citrus) and waxes (soy, castor, dimerized fatty acids, etc.) represent some key examples.
- (…)

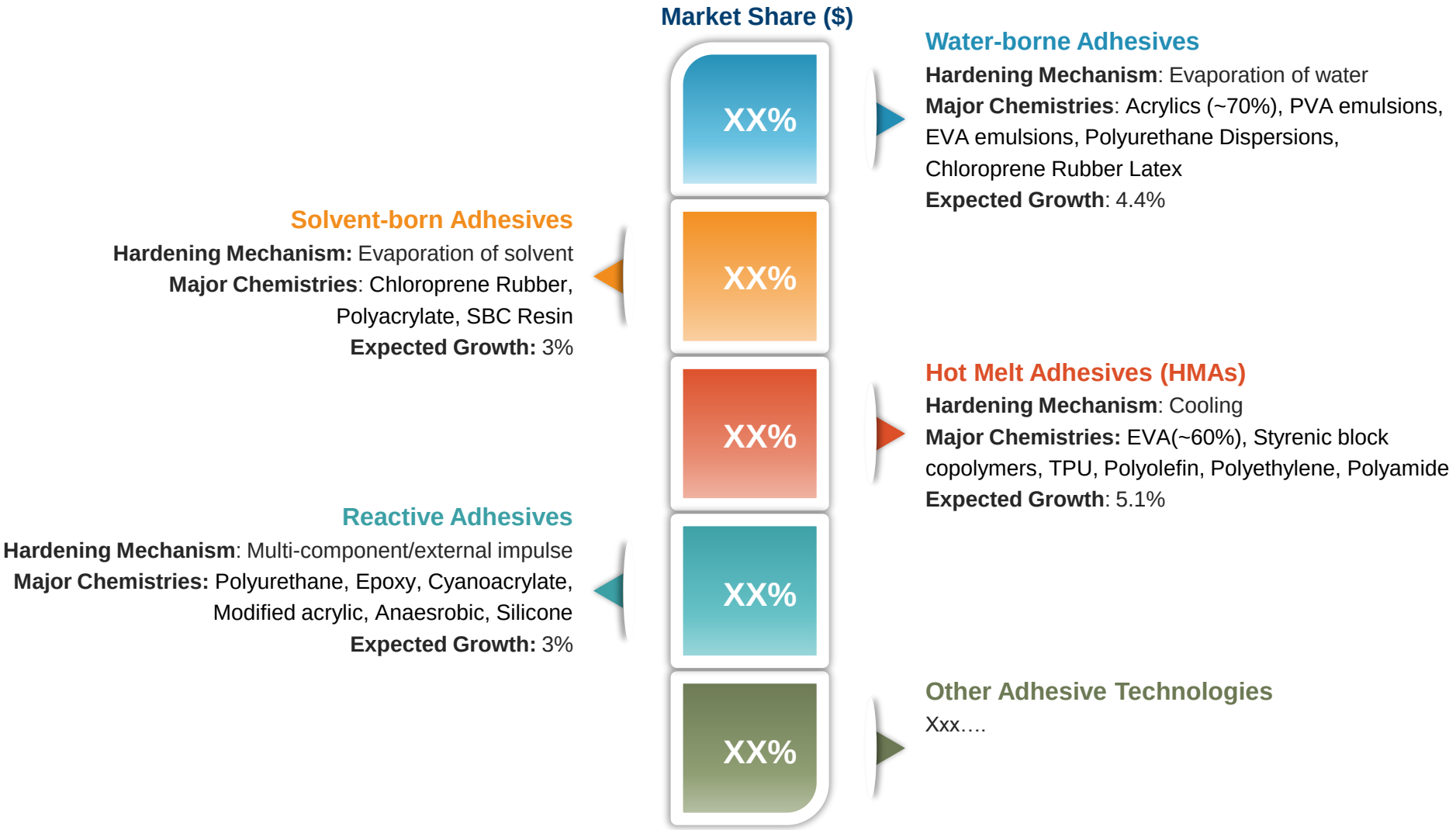
Market

Shifting Market Focus

- Recent regulations on traditional adhesives due to issues such as toxicity and emissions have stimulated adoption of sustainable/bio-based adhesives.
- Customers from construction, packaging, and textile industries are willing to spend more on sustainable products made using bio-based materials like starch, lignin, and cellulose formulations. Major adhesive manufactures are collaborating/ investing within the value-chain, mainly with bio-polymer/resin developers, e.g., Henkel and DaniMer Scientific.
- (…)

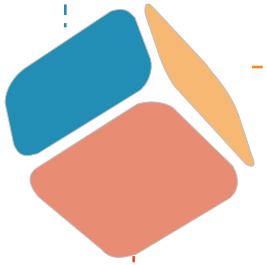
SAMPLE REPORT CONTENTS

Current Adhesive Technologies and Chemistries



SAMPLE REPORT CONTENTS

Sustainable Adhesives: Ways to incorporate Biomaterials in Adhesives



1 Natural macromolecules as Biopolymers

- Availability of multiple functional groups and other properties of plant and animal based macromolecules can be further modified to obtain high performance adhesives. Major macromolecules employed in adhesive applications are:
  - **Lignin**
  - **Polysaccharides (Starch, Cellulose)**
  - **Proteins (Milk Proteins, Soy Proteins)**
  - **Others**

2 Building biopolymers using renewable monomers

- Using the building blocks or monomers derived from renewable sources and polymerized to obtain the corresponding bio-polymers. Vegetable oil is the main source of such monomers like succinic acid, itanoic acid, propanediol, etc. Major relevant biopolymers developed are:
  - **Bio-Polyurethanes**
  - **Bio-Epoxy resins**
  - **Bio- Polyesters**

3 Renewable compounds as Additives

- Even though the share of additives present in adhesive formulations remains minor it can contribute towards enhancing the sustainability factor. Major bio-additive classes used in adhesives are:
  - **Tackifiers**
  - **Plasticizer**
  - **Rheology Modifiers**

SAMPLE REPORT CONTENTS

Overview

Lignin Overview

Chemistry: Lignin is a biopolymer produced via radical polymerization of monomers called Monolignols (phenylpropane units).

Source: Lignin is produced from wood pulping operation. There are four commercial extraction methods: Soda Process, Kraft Process, OrganoSolv Process and Sulfite Process. Based on the quality required, lignin can be recoverd through any of these processes.

Application Field: Major lignin-based adhesive are used in wood adhesives, paper adhesives, floor coverings, etc

Adhesive Features

- Lignin can be incorporated in various adhesive systems either as reacting starting material, copolymer or additives.
- The high phenolic content of lignin is suitable for replacing phenols from synthetic resins, which further adds fire retardancy to the resins.
- The high molecular weight and low chemical reactivity of natural lignin due to limited active sites is addressed by physical and chemical modifications.
    - Physical modification methods: Solvent Fractionation, Ultrafiltration or Nano-processing
    - Chemical modification methods: Demethylation, Phenolation, Methylolation, Etherification, Pyrolysis or Hydrolysis

- Higher/fluctuating price of petrochemicals force manufactures to find alternatives like lignin. *e.g. phenol in phenol formaldehyde (PF) resins*
- Helps in reducing the emission of formaldehydes from wood adhesives and toxicity involved with Phenol in PF resins.

- Unmodified lignin has low reactivity towards formaldehyde or other aldehydes
- Long curing time at elevated temperatures
- Highly corrosive behavior towards processing equipment
- Higher cost of purer lignin or reactive lignin

Current Research Areas

Blending with other polymers:

- To improve the moisture resistance of soy-protein-based adhesives, it is blended with lignin
- Blending lignin with PVAs will reduce the environment impact associated with the oil-based polymers
- Nano-crafted Lignin is blended with PVA for improved thermal stability
- Addition of lignin to formaldehyde resins reduce the formaldehyde release and improve water resistance.

01

Lignin is used as copolymers:

- **Lignin-phenol-formaldehyde adhesives:** Up to 50% of the phenol can be substitutes in PF resins forming kraft lignin phenol-formaldehyde (KLPF) resin. Also Organosolv lignin can also be used up to 30%.
- **Lignin-tannin-based adhesives**: These adhesives constitutes 94% of environment-friendly and natural polymeric materials. And they share of lignin can go up to 50%.
- **Lignin-polymethylene polyphenyl isocyanate (pMDI)-based adhesives:** Glyoxalated lignin was incorporated into polymethylene polyphenyl isocyanate (pMDI) to have an adhesive with good bonding strength.
- **Lignin-furfural-based adhesives**: It is possible to replace phenol and formaldehyde with lignin and furfural respectively in PF resin systems.

02

Lignin as a monomer/ reactive raw material:

- **Polyurethanes:** Lignin contains large number of phenolic and aliphatic hydroxyl groups which substitutes macro polyol component in PU. Bio-PU are more biodegradable than those obtained from petroleum-based polyol.
- **Polyesters:** Lignin undergo polymerization to condensation reactions for polyester synthesis.
- **Epoxide Resins:** Even though lignin comprises no epoxides naturally its macromonomer phenolic structure can be used in the synthesis of epoxide resin as a crosslinking agent/ Hardener.
- (…)

03

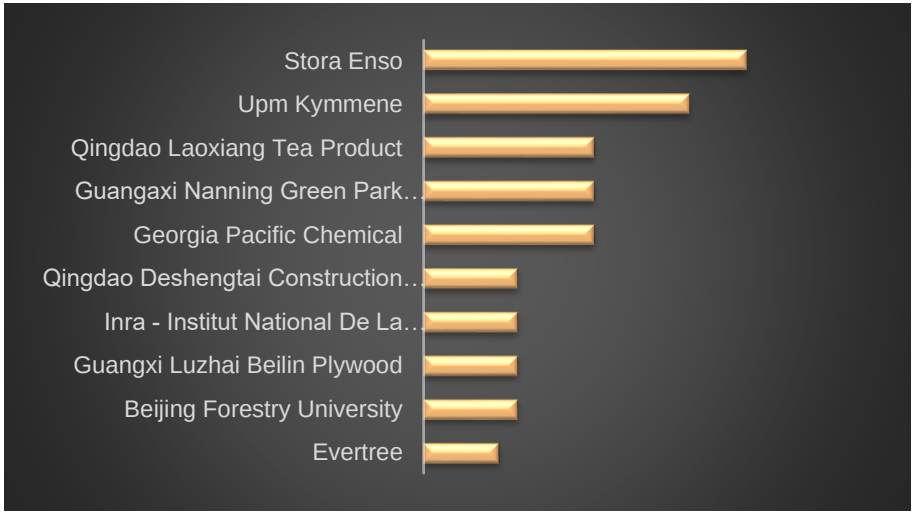
Patent Activity

Filing Trends for the last 5 years

Publication Year Vs Number of Patents

Top Players

Number of Patents



- The published patent counts are increasing gradually over the last five years, indicating research shift towards lignin-based adhesives
- **StoraEnso** leads with total 17 patents published in last 5 years with good geographical coverage.
- WO2019202478A1**: StoraEnso** Unveils bio-based lignin to replace oil-based phenolic materials. The adhesive formulation comprises phenol-formaldehyde (PF) resin and/or **lignin-phenol-formaldehyde (LPF**) resin.
- (…)

Value Chain

Lignin Manufacturers	Lignin-based Adhesive Developers
StoraEnso, Domsjö Lignin, Domtar, West Fraser, Attis Industries, UPM	Latvijas Finieris, Chimar Hellas S.A., UPM
▪ **StoraEnso** introduced **Lineo™**, where lignin is a renewable replacement for oil-based phenolic materials used in resins for plywood, oriented strand board (OSB), laminated veneer lumber (LVL), paper lamination and insulation material.(Link) ▪ (…)	▪ **Latvijas Finieris** has a new green glue **RIGA ECOlogica** where phenol is replaced with bio-based renewable lignin. It is developed for their RIGA birch plywood. (Link) ▪ (…)

Collaborations

Kaneka & VITO

For developing improved Modified Silane(MS) polymers based on lignin. The properties like moisture resistant, rigid structure of lignin is exploited to produce elastic adhesives.

Development of reference plant at Delfzijl for Zambezi Process; this breakthrough technology converts woody biomass into sugars and lignin.

(Player A & Player B)

(Player A & Player B)

Project to replace formaldehyde in phenol-formaldehyde (PF) resins with 100% bio-based lignin-HMF resins.

Working together on the patented technology for one type of protein adhesive containing lignin and ground plant meal or an isolated polypeptide composition obtained from plant biomass.

(Player A & Player B)

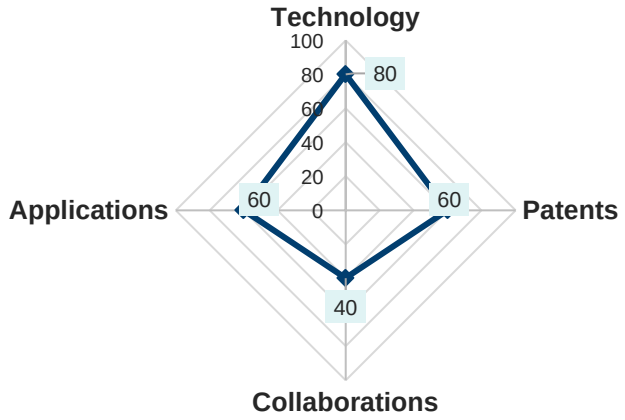
Natural Macromolecules | Lignin

Aranca Technology Assessment

Final Score Xx/30

Assessment Factors	Details	Criteria	Low 1	2	Score 3	4	High 5	Total
Technology	▪ Lignin based products are already in market, but lignin-based adhesives with 100% renewable content were absent.	TRL						x
		Renewable Contents						
Patents	▪ (details…)	No of Patents Published						x
		Patent Status						
Collaborations	▪ (details…)	No of Collaborations						2
Applications	▪ (details…)	Target Applications						3

Aranca Technology Assessment



Opportunities

- (observation…)
- (observation…)

Note: Factor scores have been normalized on a 0-100 scale.

SAMPLE REPORT CONTENTS

Renewable Adhesive Technologies

SAMPLE REPORT CONTENTS

Key Players | Profile

Henkel

Key Company Info

Company Name	Henkel AG & Company, KGaA
Founded	1876
Website Address	https://www.henkel.com/
Headquartered	Düsseldorf, Germany
Revenue	$22.4B (2019)

Technology & Product Development

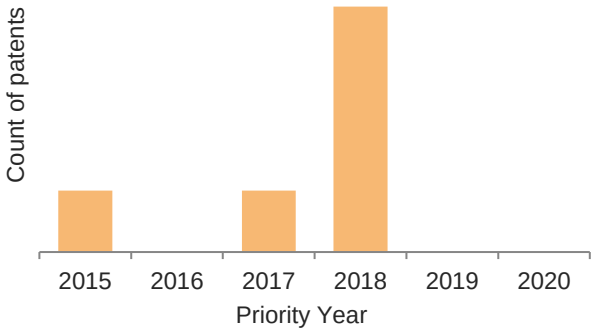
Chemistry: **M**ajor adhesive chemistries under research are **Bio-polyurethanes, Lactic acid-based resins, and Starch** based adhesive compositions.

Application Areas: Packaging | Labelling | Health-care | Electronics(battery bonding)

Commercial Products: Macromelt a new-patented bio-additive for plastics processing. The product impart improved adhesion and reduced water absorption property.

Patent Focus: Bio-based HMAs | Moisture-curable adhesives

Patent Filing Trend



Note: Only patents focusing on the bio-based composition developments are considered

Collaborations & Partnerships

- Collaborating with raw-material supplier **ExxonMobil**, Henkel has developed a full PE laminated stand-up pouches (SUP) . The new SUP packages contain up to 30% recycled SUP content, including recycled adhesive, and offer performance that is on par with existing packaging.
- **Borealis** and Henkel are also working on a pilot for a full PE laminate stand-up pouch that contains both virgin and recycled ingredients with 35 percent post-consumer recycled-LDPE.
- Invested on **Saperatec**, a Germany-based startup that has developed a unique technology to separate multilayer packaging films, with the aim of developing and enhancing customized recyclable adhesives.
- Henkel and **DaniMer** formed alliance to deliver bio-based hotmelt adhesives for packaging. They have patented technology for the bio-HMAs.

aranca

BUSINESS RESEARCH
& ADVISORY

INVESTMENT RESEARCH
& ANALYTICS

VALUATION
ADVISORY

TECHNOLOGY
INTELLIGENCE &
IP RESEARCH

PROCUREMENT & SUPPLY
CHAIN INTELLIGENCE