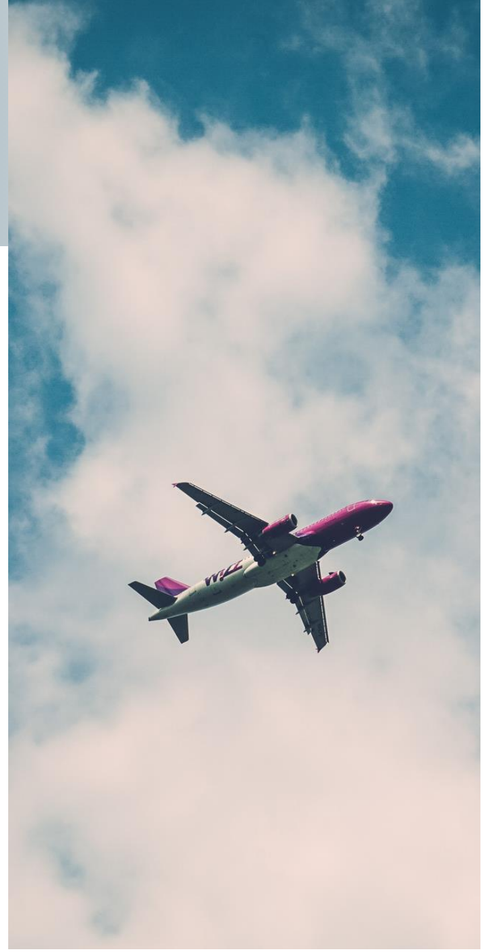
Perspectives on (the future) of debonding

AFERA Annual Conference 2021



RESCOLL

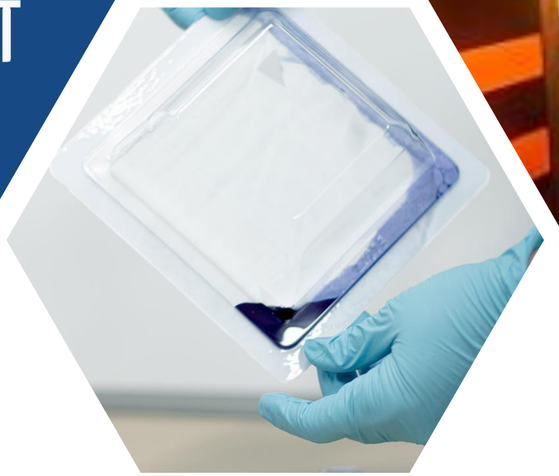
16M€
TURNOVER

12000 M²
LAB SURFACE

› 1M€
ANNUAL
INVESTMENT

› 1000
CUSTOMERS

150
EMPLOYEES



OUR ACTIVITIES

TESTING

PHYSICO-CHEMICAL ANALYSES

STATIC & DYNAMICAL MECHANICAL TESTING

FIRE TESTING

SURFACE & COATINGS ANALYSIS

ABUSE TESTS ON STRUCTURES

R & D

INNOVATION

CONTRACTUAL R&D

EXPERTISE

SERVICES

AUDIT

TRAINING

MACHINING & ASSEMBLY

TOLL MANUFACTURING

PRODUCTS

ADHESIVES

- STRUCTURAL ADHESIVES
- DEBONDING ON-DEMAND

TECHNICAL COATINGS

- PAINTS
- SOL-GEL COATINGS
- LEATHER

OUR SITES

1 RESCOLL (HEAD OFFICE)

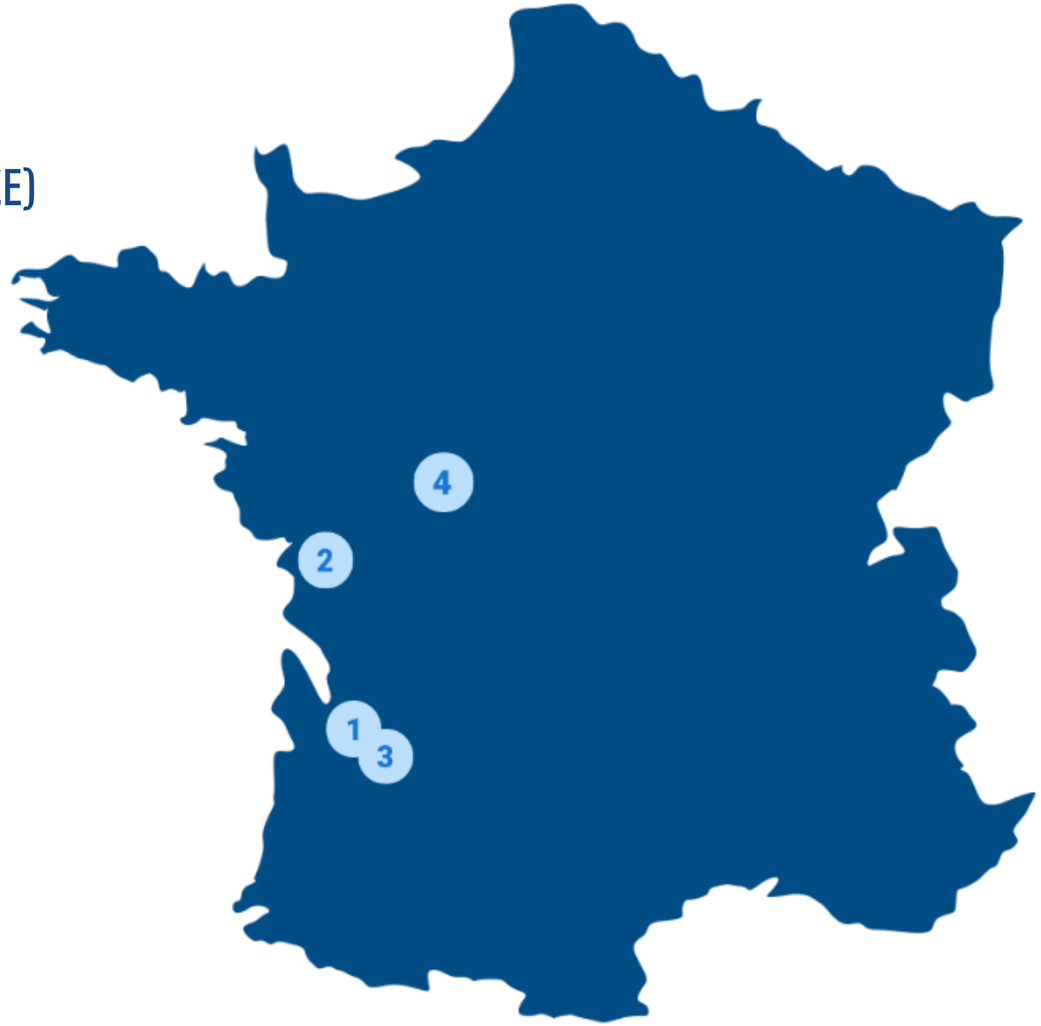
PESSAC (33)
-HQ & SUPPORT FUNCTIONS
-R&D
-TESTING
-SERVICES

2000

2 RESCOLL

ROCHEFORT (17)
-TESTING
-MACHINING

2016



3 RESCOLL MANUFACTURING

GRADIGNAN (33)
-MACHINING
-ASSEMBLY

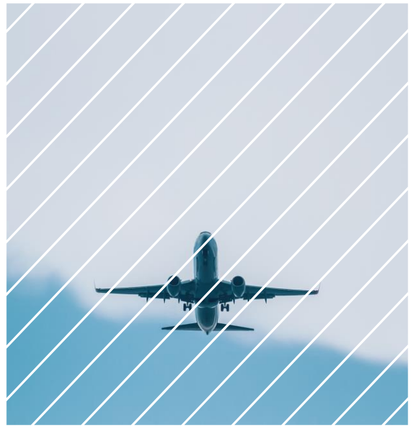
2012

4 STILZ

NAINTRÉ (86)
-FINISHED GOODS PRODUCTION

2015

BUSINESS SHARE



ASD

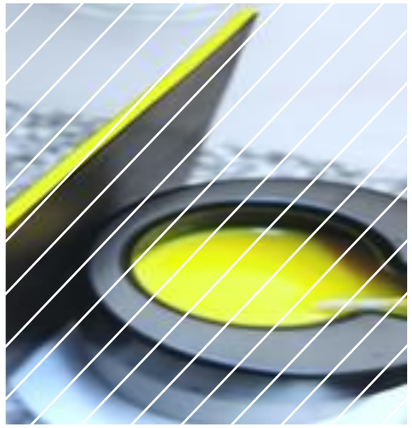
25%

HEALTH
MEDICAL DEVICES

30%

ENERGY

15%



LEATHER
INDUSTRY

10%

OTHER
INDUSTRIES

20%

DEBONDING ON DEMAND

THE CONTEXT

- Bonding and need for disassembly: an up and coming couple!
- High performance adhesives : rather new, still a lot to learn and understand on adhesion and durability
- Debonding on command: a paradox!
- Access to information on debonding:
  - not easy
  - few products in the market
  - numerous keywords (eg: debonding often stands for delamination)

DEBONDING ON DEMAND

THE CONTEXT

Debonding of standard adhesives is mainly based on

- **Thermal degradation of the adhesive**
- **Cutting of the adhesive**
- **Use of solvents**
- **A combination of these methods**

DEBONDING ON DEMAND

THE CONTEXT

Debonding of standard adhesives mainly based on :

- **Time-consuming operations**
- **Invasive methods (heat, solvents) with risks of substrate damage**
- **EHS issues**
- **Dismantling of cured adhesives (even if not structural) is always more complex (no melting or easy solvent swelling)**

➡ ***Clear need for easy, quick and reliable debonding techniques based on switchable adhesives***

DEBONDING ON DEMAND

THE CONTEXT

Debondable adhesives and Environment

Debonding and Demand as a possible (partial) solution for regulatory issues

- ELV (2000/53/EC): sorting of bonded parts, dismantling of dissimilar materials
  - Glazing
  - Hybrid assemblies (TP on Thermoset composites)

- Electronics and Consumer goods: 2002/96/EC then 2012/19/EU

DEBONDING ON DEMAND

Requirements for a debondable adhesive

Processing

- Similar to adhesives used for the application
  - No specific tool/machine needed
  - No shelf life or gel time limitation

Life in service

- Similar to standard adhesives
- No anticipated debonding of the parts or decrease of the adhesive strength of the assembly
- Ageing performance and durability should remain unchanged

Debonding step

- Easy and unambigous triggering (i.e. activation must be simple and reliable)
- As fast as possible (depending on the parts to disassemble)
- Clean substrates surfaces after debonding (easier re-use, recycling of the parts)

Main idea: How to find a compromise between durability and the release function?

DEBONDING ON DEMAND

APPLICATIONS

MAINTENANCE

- Replacement of worn parts
- Upgrade of components

END OF LIFE

- Sorting-recycling
- Recovering of parts

TEMPORARY FIXING

- Machining
- Proof tests
- Bonding of sensors (on planes, cars, ...)

ECO DESIGN

- Reversible bonds: substitute to traditional reversible joining methods (screwing, riveting).
- Dual positive environmental impact of the bonding process: lighter assemblies and less processing energy
- Dismantling allows recovering of parts and material savings

Adhesive (>2%) is locking 98% of the total mass!
Shredding-landfill is the most probable scenario...

DEBONDING ON DEMAND
APPLICATIONS

The tapes case …

Many use cases (recycling, repair, …)

Road signs

Construction
(glazing, multimaterial panels)

Consumer electronics

Soft goods

Automotive
(interior trims, nameplates,
cameras, mirrors, …

Medical devices

DEBONDING ON DEMAND

STRATEGIES

Different technical approaches developed so far for debonding on command…

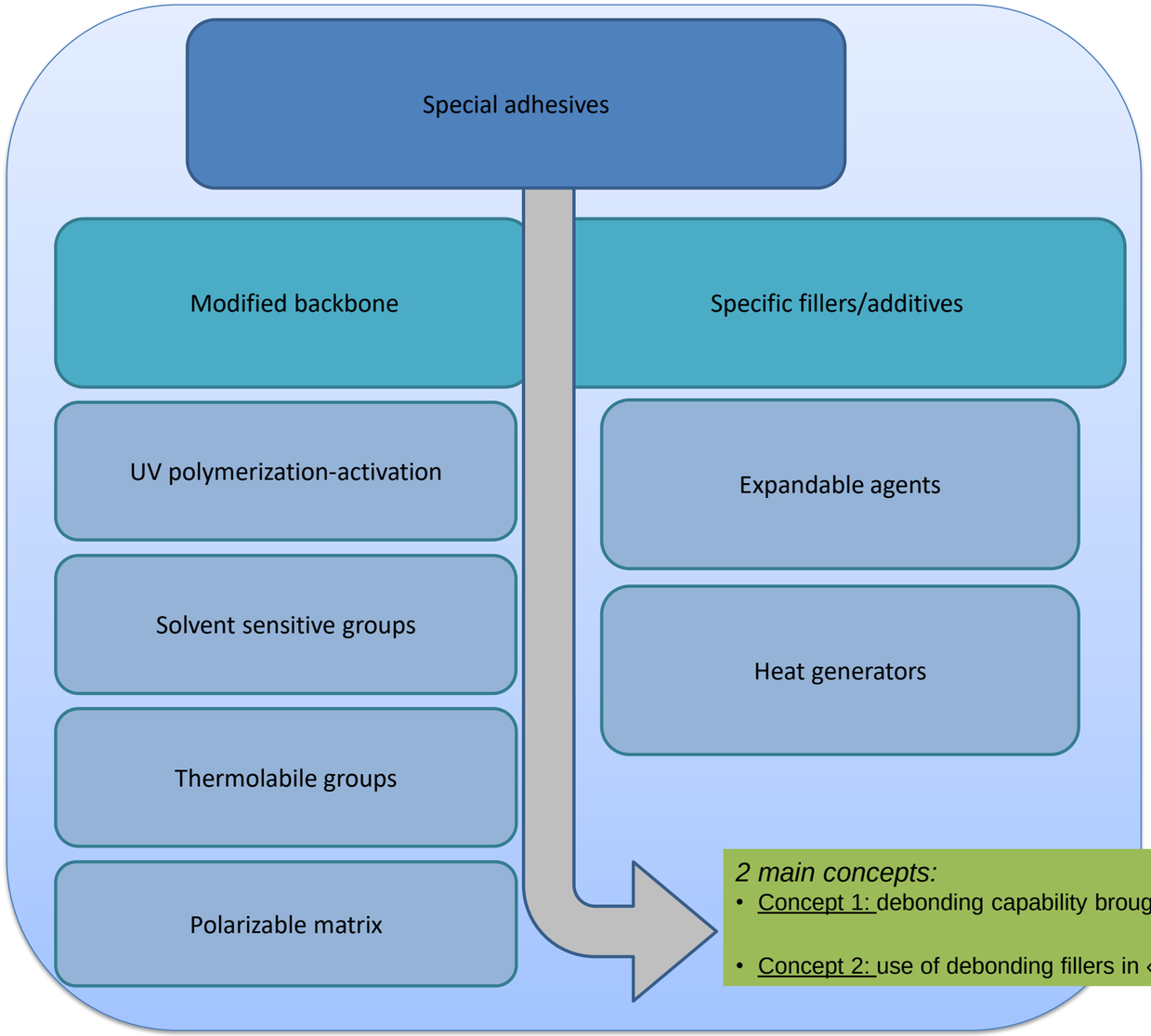
2 main concepts:

- **Modified resins with intrinsec debonding features**

- **Addition of special additives**

DEBONDING ON DEMAND

STRATEGIES



2 main concepts:

- Concept 1: debonding capability brought by a specific backbone
- Concept 2: use of debonding fillers in « standard » formulations

DEBONDING ON DEMAND

STRATEGIES

Concept 1: Modified backbone

Modified resins with intrinsec debonding features:

- **Quick and controlled degradation under specific conditions**
- **No impact on adhesive cure**
- **Simple and cheap chemical modification of the adhesive**
- **Performances similar to unmodified resins**

DEBONDING ON DEMAND

STRATEGIES

Concept 1: Modified backbone

Main developments based on PSAs: 2 concepts: loss of tack or depolymerization

Loss of tack with UV radiations

- Degradation of the chain (sulfone functions)

Rivaton et al, Polym. Degrad. Stab., 66, 385-403 (1999)
Li et al, Reactive and Fonctional Polymers, 42, 59-64 (1999)

- Post curing (change of the mechanical properties , adhesive is more rigid, less tacky)

Barwich et al, Adhesives Age, 4, 22-24 (1998)
Webster, Int. J. Adhesion Adhesives, 19, 29-34 (1999) (Smith & Nephew)
Similar concept with Lumina Adhesives or Nitto (JP2001200215) or 3M (US4286047)

Typical wavelength range: 185 to 400nm (penetration depth is better at l>300nm)

DEBONDING ON DEMAND
STRATEGIES

Concept 2: Addition of special additives

Objectives of the formulation

- Activation by a specific stimulus
- No impact on adhesive cure and stability
- No impact on adhesive service life (no premature activaiton)
- No depletion of the mechanical performance of the adhesive

Addition possible in commercial formulations (direct reformulation) or custom formulas

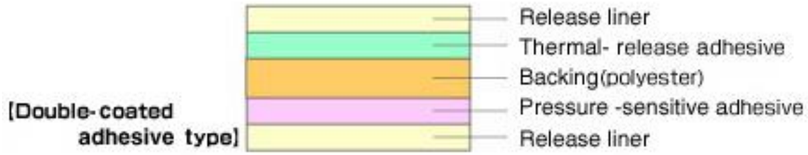
DEBONDING ON DEMAND
STRATEGIES

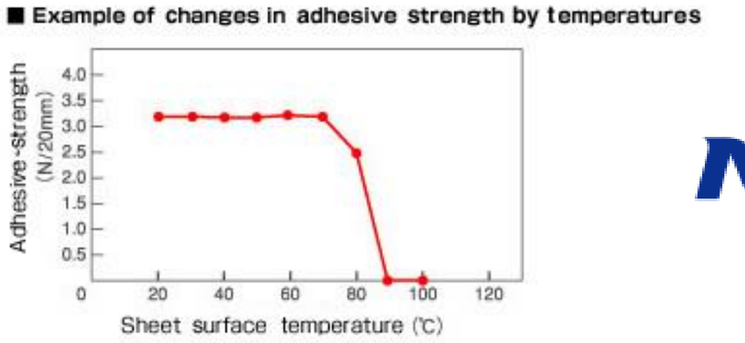
Concept 2: Addition of special additives

Expandable agents

Physical blowing agents: Thermoexpandable microspheres

Example of commercial tapes including TEM
***•NITTO DENKO Revalpha (Patent* EP 2204425)**

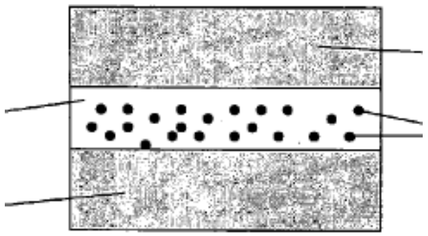




Nitto

•TESA patent
•WO2006042782 (2006) : PROCESS FOR RECYCLING ELECTRONIC COMPONENTS
Expandable microparticles in the tape. Possibility to add induction sensitive fillers to boost heating

tesa®

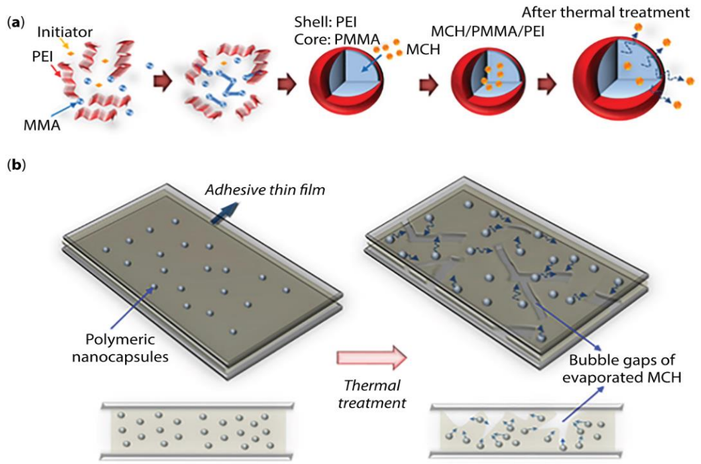


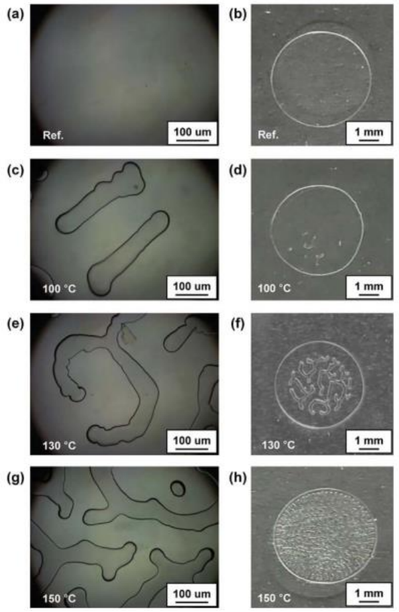
DEBONDING ON DEMAND
STRATEGIES

Concept 2: Addition of special additives

Expandable agents

Physical blowing agents: Other encapsulated blowing agents





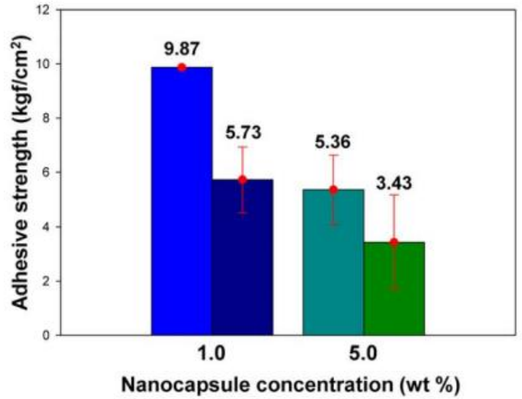


Figure 8. Adhesive strengths of untreated (left bar) and heat-treated (right bar) adhesive thin films containing 1.0 and 5.0 wt % nanocapsules after thermal treatment for 5 min at 150 °C. [Color figure can be viewed at wileyonlinelibrary.com]

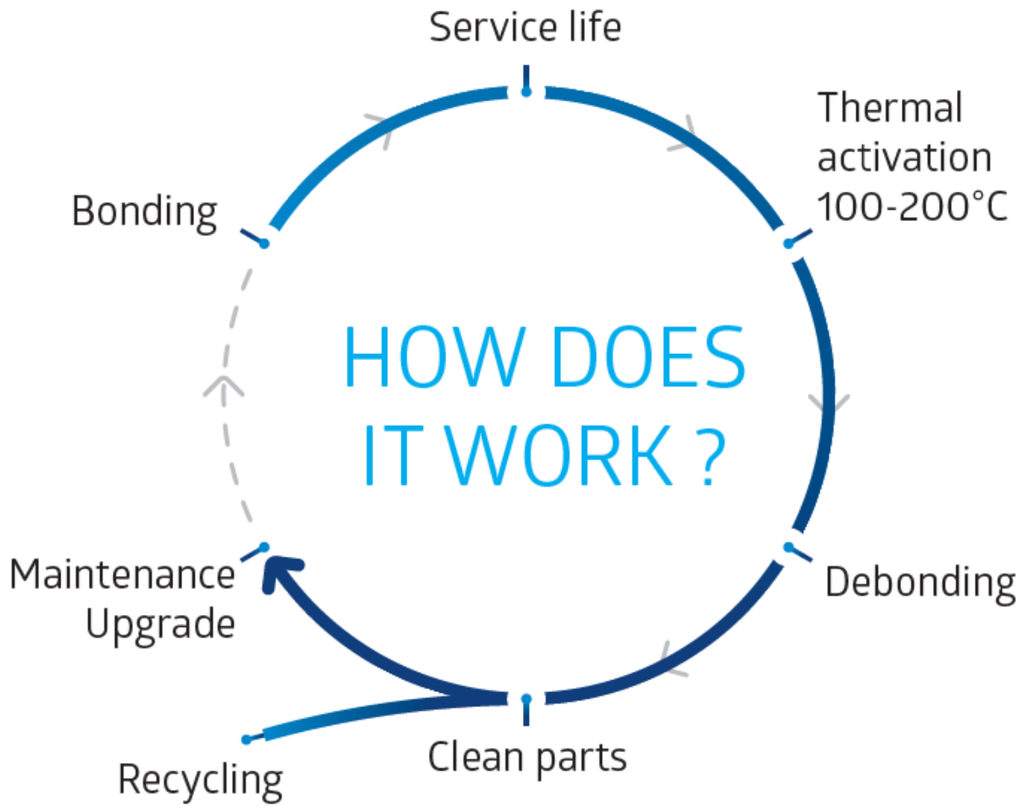
B. Lee *et al.*, "Polymeric nanocapsules containing methylcyclohexane for improving thermally induced debonding of thin adhesive films," *J. Appl. Polym. Sci.*, vol. 135, no. 31, pp. 1–9, 2018.

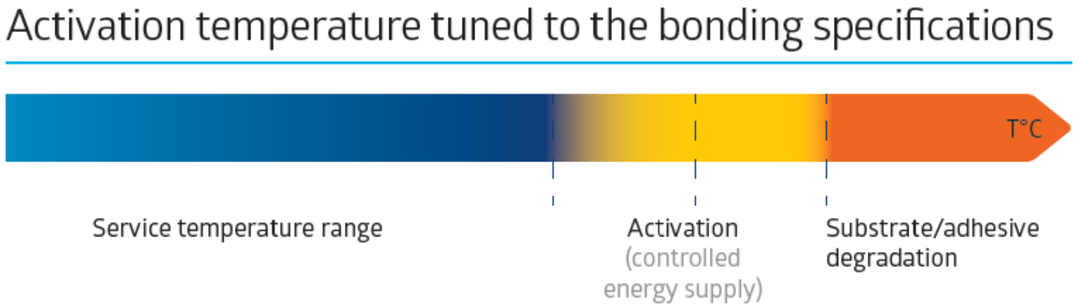
DEBONDING ON DEMAND

INDAR PRIMER

Thermally triggered primer for on demand debonding or stripping

Patented





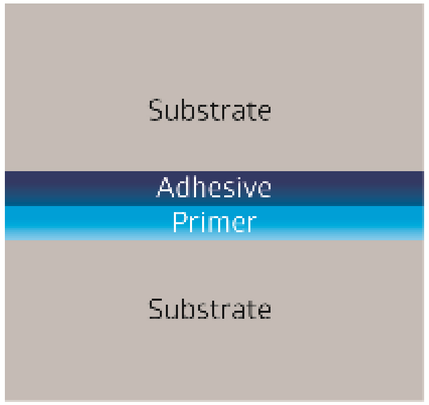
DEBONDING ON DEMAND

INDAR PRIMER

Service life of the product

End of life / recycling process

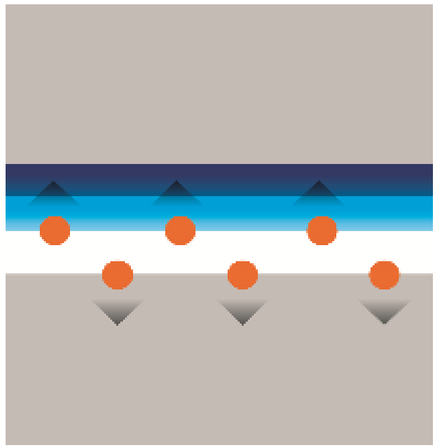
Primer compatible with most adhesives or coatings



indar inside

Thermal activation

100°C-200°C



Easy debonding
very low residual strength

Clean substrate to be recycled or reused without any adhesive residue

No effect on the high mechanical properties of the adhesives during service life

No activation during product lifecycle

Once activated, debonding is irreversible and separation can be done at lower temperatures

Activation temperature below substrate degradation temperature

DEBONDING ON DEMAND

INDAR PRIMER

INDAR DEBONDING PRIMER IS COMPATIBLE WITH ALL ADHESIVES OR COATINGS WITHOUT ANY EFFECT ON THE MECHANICAL PROPERTIES OF THE ASSEMBLY DURING SERVICE LIFE

ONCE THERMALLY TRIGGERED ON-DEMAND, THE PRIMER ACTIVATION ALLOWS AN EASY AND CLEAN DISASSEMBLY

FEATURES

- No activation during service life
- High mechanical properties (›15MPa)
- Very low residual strength (‹1MPa)
- Compatible with all adhesives/coatings
- Preferential debonding on selected surface
- Easy separation and post cleaning

PROPERTIES

COMPONENTS	1K (solvent based)
COLOR	Transparent or Blue *(any color on demand)*
SUPPORT	Any substrate
THICKNESS (DRY)	15-20 µm
APPLICATION	Spray, Brush, Jetting, Screen printing
DRYING TIME	5 min @23°C under normal conditions
THERMAL ACTIVATION	100°C - 200°C Oven heating 5min, IR heating 2-5 min, Induction heating
MECHANICAL PROPERTIES	Before activation ›15MPa Residual strength ‹1MPa
CLEANING	INDAR Cleaner

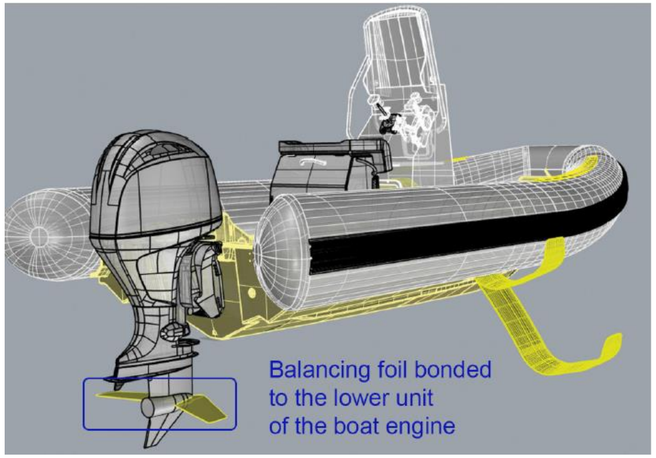
Data provided for information only - not for specifications

DEBONDING ON DEMAND

INDAR PRIMER

USE CASE (1 example)

SEAIR: Debonding of composite foils



Source: SEAIR

Source: SEAIR

Bonded assembly: composite foil bonded on steel frame of engine, need for repair of foil / refurbishing of engine (2nd hand market)

- *Easy implementation of bonding (manual in composite workshop)*
- *Mechanical and environmental resistance proven (>100h of navigation, various conditions)*
- *Easy debonding with simple heating system, easy refurbishing of the motor and possible reuse of the foil*

Many other use cases under evaluation!

https://rescoll.fr/jec-2020-design-for-disassembly-of-bonded-composite-foils-by-rescoll-and-seair/

DECOAT

Horizon 2020
European Union funding
for Research & Innovation

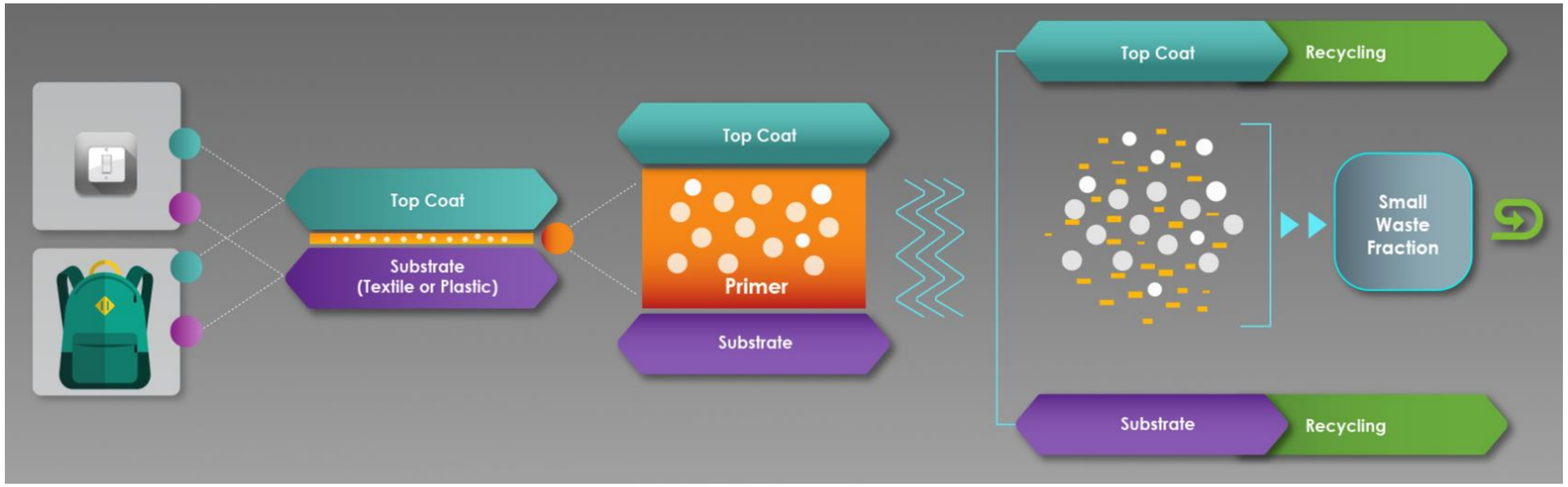
RESCOLL

Coordinator: Centexbel (BE), 17 Partners

Objective

Recycling of coated and painted textile and plastic materials.
The main goal of DECOAT is to enable circular use of textiles and plastic parts with (multilayer) 'coatings', which are typically not recyclable yet. These 'coatings' comprise functional and performance coatings and paints as well as adhesion layers.

Main concept



http://decoat.eu/

DECOAT

Horizon 2020
European Union funding
for Research & Innovation

SEVERAL USE CASES

- Automotive painted parts (MAIER)
  - Stripping of the paint layers from the plastic parts
  - Recycling of virgin plastic without paint residues

- PU foam cockpit parts (MERCEDES BENZ)
  - Debonding of the skin to foam
  - Separation of 2 dissimilar materials -› recycling allowed

- Coated Textiles (VAUDE-CENTEXBEL)
  - Stripping of coatings from fabrics
  - Enhanced recycling of fabrics

CONCLUSION

- **More regulatory pressure on goods manufacturers regarding end of life**
  - Needs for recycling, especially new and widespread dissimilar assemblies and coated materials
  - Easier recovery/maintenance of parts is targeted to extend product life span

- **Debonding/stripping on command gives an open choice to engineers and designers** for materials assembling: adhesive may be considered for applications where lack of reversibility is a No-Go. Same for coated materials like plastics @ EOL

- But strategies and will for debonding/stripping on demand depends on product value and service life + end of life

- In most cases, **working on easy separation and reuse** of dissimilar materials has **more impact than working on biobased materials**

CONTACTS

TECHNICAL SUPPORT
MAXIME OLIVE
MAXIME.OLIVE@RESCOLL.FR

SALES
CEDRIC DAUGA
CEDRIC.DAUGA@RESCOLL.FR