ECODISM Project

Goals and main outcomes

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Saint-Gobain Sekurit

TRA Conference, April 24th, Ljubljana, Slovenia

Bonds that debond...
an ecoconception of cars for further environmental friendly dismantling
ECODISM goals and main outcomes

Contents

- What is Ecodism?
- Ecodism & ELV context
- Main achievements, and their impacts
- Conclusions
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**Definition and Objectives**

“Ecological and Economical development of innovative strategy and process for clean maintenance and dismantling and further recycling of vehicle parts”

**Objectives**

The main objective is to provide to the automotive industry and to car dismantlers effective technologies and methodologies for cost-effective, environmental friendly dismounting adhesive joined parts or components.

- Facilitate maintenance of glazing, plastics/composites, and aluminum parts.
- and dismantling of those part, leading to ASR Reduction
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<td><strong>Project Acronym:</strong></td>
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<td><strong>STREP Number:</strong></td>
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<td><strong>Coordinator:</strong></td>
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<td><strong>Partners involved:</strong></td>
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ECODISM goals and main outcomes

How does that work? (glazings example)

1) Designing of adhesive system by embedding active species in the primer layer (or adhesive bead)
2) The system stays dormant during the whole vehicle life (expected 15 years)
3) At end of life, quick radiative sollicitation during dismantling stage
4) Will provide easy dismantling within short time (1-2mn)
ECODISM goals and main outcomes

- **Research Axes**

  - Car manufacturers & Dismantlers
    - Specifications – Protocols
  - BONDS THAT DEBONDS
  - Adhesives and formulation
  - Assembly Line compatibility
  - Energy sources – Optimisation and modelling
ECODISM goals and main outcomes

- Specifications & protocols:
  - Materials to bond (example: Glazing / Painted metal sheet, Composites / Composites, Glazing / Plastics, Aluminum / Aluminum)
  - Geometry
  - Application methods of adhesives
  - Dismantling (specifications, protocols) and
  - LCA / LCC
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Research Axes

- **LCPO**
- **RESCOLL**
- **EFTEC**
- **EXPANCEL**
- **DEBONDING Ltd.**

Adhesives and Active Systems:

- Integration of active systems within adhesive (thermo-expandable microspheres, blowing agents…)
- Formulation of adhesives
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Research Axes

Assembly Line Compatibility:
- Application of adhesives on concrete examples
- Tests on application methods
- Ensure bonding durability
- Ensure the durability of the de-bonding capability
- Full scale tests

SGS
FIAT
PO

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Research Axes

Energy sources – Optimisation and modelling:

- Selection of Adapted Activation Sources (IR, UV, MicroWave...)
- Computer Modelling of delivering method energy
- Computer Modelling of the debonding Process
ECODISM goals and main outcomes

- Ecodism Project members:

  - Ceramicx
  - DE-BONDING Limited
  - AKZO NOBEL
  - SAINT-GOBAIN
  - RESCOLL
  - indra
  - ALMA Consulting Group
  - INASMET tecnalia
  - Italy
  - Plastic Omnium
  - Fiat Group Automobiles SpA

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## ECODISM goals and main outcomes

### Roadmap

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<th>Car manufacturers &amp; Dismantlers Specifications – Protocols</th>
<th>Final Report on LCA</th>
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<td>Specifications</td>
<td>Dismantling protocol</td>
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<th>Adhesives and formulation</th>
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<td>First generation of adhesive active systems</td>
<td>Second generation of adhesive active systems</td>
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<th>Assembly Line compatibility</th>
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<td>Assembly methods</td>
<td>Final reports on bonding and debonding durability</td>
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<th>Energy sources – Optimisation and modelling</th>
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<td>Results for the different sources – Computer model of the debonding process</td>
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ECODISM goals and main outcomes

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Between 9 and 12 million cars are discarded each year in EU. It creates an important amount of non-metallic waste which ends up in landfills.

Automotive Shredder Residue (ASR) reduction is of prime importance. EC Directive 2000/53 fixes strict targets concerning the reuse, recovery and recycling of materials in ELVs:

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<th>2006</th>
<th>2015</th>
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<td>Reuse and recycling</td>
<td>80 %</td>
<td>85 %</td>
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<td>(% of vehicle weight)</td>
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ECODISM goals and main outcomes

- **Motivations**

Dismantling of some parts may lead to direct ASR reduction

![Bar chart showing expected values before and after ECODISM](chart.png)

- **As of 2004**
- **Expected values after ECODISM**

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Motivations: example of car glazings

- Car glass represents today ~3% of the weight of a car
- although car glass quite easy to recycle back to glass furnaces as cullet (Insulated glass; containers)..
- ...glass is currently not recycled and goes to ASR
- it represents ~300,000 T of glass cullet lost, all along the ELV chain !!!
- ECODISM will enhance possibilities of clean dismantling and easy recuperation of glass bonded parts
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Motivations: example of plastic tailgates

Interesting composite for tailgates now is by assembling a SMC backing (ensuring structure) and PP covershield (external durability), by bonding.

Recyclibility requirements of car maker’s is to allow separations of both at ELV.

ECODISM provides direct solutions.
ECODISM goals and main outcomes

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- Active system 1:

**Thermo-Expandable Microspheres (TEMs), by**

- Microspheres are embedded in the primer
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- Active system 2: Chemical agents: Indar, by

  - Melting $\rightarrow$ Migration at the interface $\rightarrow$ Decomposition of the agent
  - After Cooling: Weak Cohesion Layer
  - 2 possibilities: Bulk Formulation or Primer Integration

Example: pTSH molecule
(Melting Point = 105-110°C)

Lap shear test on Al/Primer/Epoxy/Al

Max Strength (MPa)

- BLANK
- PRIMER WITH pTSH
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- TEMs activation = primer expansion

- in-depth studies at LCPO
- Dedicated grade of TEM to expand in 170°C range (Akzo Nobel)
- Expansion of the primer layer occurs after Infra-Red heating up to 170°C
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- Microspheres activation = primer expansion

- Decrease in mechanical properties after activation, allowing easy distachement

- Failure propagates in the expanded primer

- Cohesive failure (in PU seal)
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- Durability of debonding function

- **Microspheres expand even after aging tests**
- **De-bonding properties are maintained, after 15 years ageing in a car**
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- **Active system 2 : Indar :**

  - 2 to 30% of suitable chemical agent mixed in PU adhesive

  ![Graph showing peel strength before and after activation](image)

  - Efficiency of the activation
  - Stability of the Adhesive

Sample: microscope glass blades

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- Active systems maybe packed in commercial adhesives

Stability of the modified primer with TEM’s (EFTEC)

Results:

- Stability of at least 3 months at ambient temperature
- No primer gelling
- Microspheres still Active after storage
- Microspheres still expand after deposition of the 2C primer & a storage period of 3 months

Same statement for Active system 2 (Indar)
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Car assembly line compatibility

- Application of those adhesives in car assembly line (Fiat)
- comply with industrial application mean
- comply to car maker’s specifications
ECODISM goals and main outcomes

**Activation methods**

- Key issue to bring energy at the proper location
- Inasmet has investigated different ways IR; UV, Microwaves; Induction
- Inasmet developed a computer tool (“THERMAL”) to easily calculate transient temperature distribution in joints.
- IR selected as the best method for the glass case
- Induction heating maybe an alternative solution with glass when bonded to metallic frame

But:

- IR direct heating on plastic demonstrated as not possible (Inasmet; LCPO; Rescoll)
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- **Activation methods : IR : Ceramicx inputs**

  - Analytical study made with glass to explain the thermal transfers: the IR radiation is absorbed by the glass and the ceramic black frame. Activation of the TEMs takes place by thermal conduction from the black enamel, not radiation.

  - Ceramicx designs quartz halogen IR emitters to support this assessment, and for the use of the different entities of the project.

  - Conception and realisation of lamp panel tool.

  - Scale 1 trials on glass are OK.
ECODISM goals and main outcomes

- Lamp panel tool from Ceramicx

Panel holding 188 heater elements, all individually monitored. Prior Calibration of the system ensures to get homogeneous temperature all around the glass.
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- Dismantling trials (Glass)

→ System has been installed in Re-Source Industry (dismantling plant)

Successful results with both active system solutions, on Windshield and Backlite of FIAT Grande Punto.
Easy dismantling, by hand, after 90 sec IR radiation for backlite, and 150 sec for windshield
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Lab trials (plastic hatchback)

- Thermal activation: IR not possible: behavioral of PP skin > 140°C
- Transposition of the results for glass not possible
- Indar technology gives best results
  - Indar within adhesive
  - Heating by hot plate through SMC side: 1min20s needed to reach the activation temperature (165-170°C)
  - 2min activation time needed to observe visual dismantling of the bonded parts
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Dismantling trials (plastic hatchback) : PO and Rescoll

- Thermal activation was provided by same mould (see below) initially designed for bonding the PP on SMC component

- after heating at the target temperature for 2 to 3 minutes, dismantling by hand (after cooling) of the different parts was possible. The kind of failure observed were similar to those obtained with the lab tests.

- The SMC frame was easily dismantled from the PP skin and relatively clean from residual adhesive. No visual degradation of the parts was noticed.
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- Outlined dismantling protocol: Glass / IR method

Plans of windscreen and rear window removal workstation (by Re-source)
ECODISM goals and main outcomes

- Outlined dismantling protocol: Glass / IR method

STEP 1

STEP 2

STEP 3

STEP 4

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ECODISM goals and main outcomes

- LCA and LCC study

Study performed by Fiat, using internally developed tools:

- **LCA (Life Cycle Analysis):** tool to evaluate the **environmental** impact of an industrial process considering the whole life of product:
  
  *Raw materials; Production; Energy consumption; Use phase; End of life*

- **LCC (Life Cycle Cost):** tool to evaluate the **economical** impact of an industrial process
  
  *Fabrication costs; Maintenance costs; Waste management costs*
ECODISM goals and main outcomes

- **LCA and LCC: evaluation**

  **Glass dismantling methods:**

  **Case 1:** Manual dismantling (piano wire)

  **Case 2:** Traditional dismantling with electric tool

  **Case 3:** Dismantling as in Re – Source plant
  - Windscreen: cutting of the glass / Backlight: glass brittle breaking

  **Case 4:** Dismantling with active systems – one lamp moving around the glass

  **Case 5:** Dismantling with active systems – static group of lamps disposed around the glazing – all lamps switched in (non optimised)

  **Case 6:** Dismantling with active systems – static group of lamps in heating panel – just lamps needed (optimised calculation)

  **Case 7:** Dismantling heating with induction
ECODISM goals and main outcomes

- LCA and LCC: evaluation

Glass dismantling methods:

Case 1: Manual dismantling (piano wire)

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Case 7: Dismantling heating with induction

Ecodism method is the best:
Best LCC performances / Only way to have an unique tool for each car glazing
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Main conclusions

- Both active systems (TEMs and Indar) are OK for Glass
- Active systems may be packed in commercial adhesives
- Such adhesives are compatible with car assembly lines
- Dismantling glass by IR method
- LCA/LCC assess the validity of this method
- Indar more proper method for plastic hatchback
- Dismantling Plastic hatchback using Indar agents and heating in the same tool used for bonding
- ECODISM significant contribution to world science of Adhesion
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- Dissemination: main facts

- Presentation at Pollutec Paris in Nov. 2007 (JL Bravet)

- Scientific paper presented at 31th Adhesion Society Meeting, Austin, US, Feb 2008 (Prof. E. Papon)

- Scientific paper presented at 2007’ French Adhesion days, Biarritz, France, Sept. 2007 (Prof. E. Papon)

- Scientific paper will be presented at EURADH’ 2008 (Oxford, UK) (Prof. E. Papon)

- 2008 TRA Conference, April 24th, 2008, Ljubljana, Slovenia

- ECODISM Final event - April 17th, Romorantin, France
ECODISM goals and main outcomes

- Ecodism final event Romorantin April 17th, 2008
ECODISM goals and main outcomes

- In Memoriam…

*Prof. Giovanni Manfrè (1933-2007)*
Thanks for your attention !!!

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