PETRU PONI

EXECUTIVE AGENCY FOR HIGHER EDUCATION, RESEARCH, DEVELOPMENT AND INNOVATION FUNDING

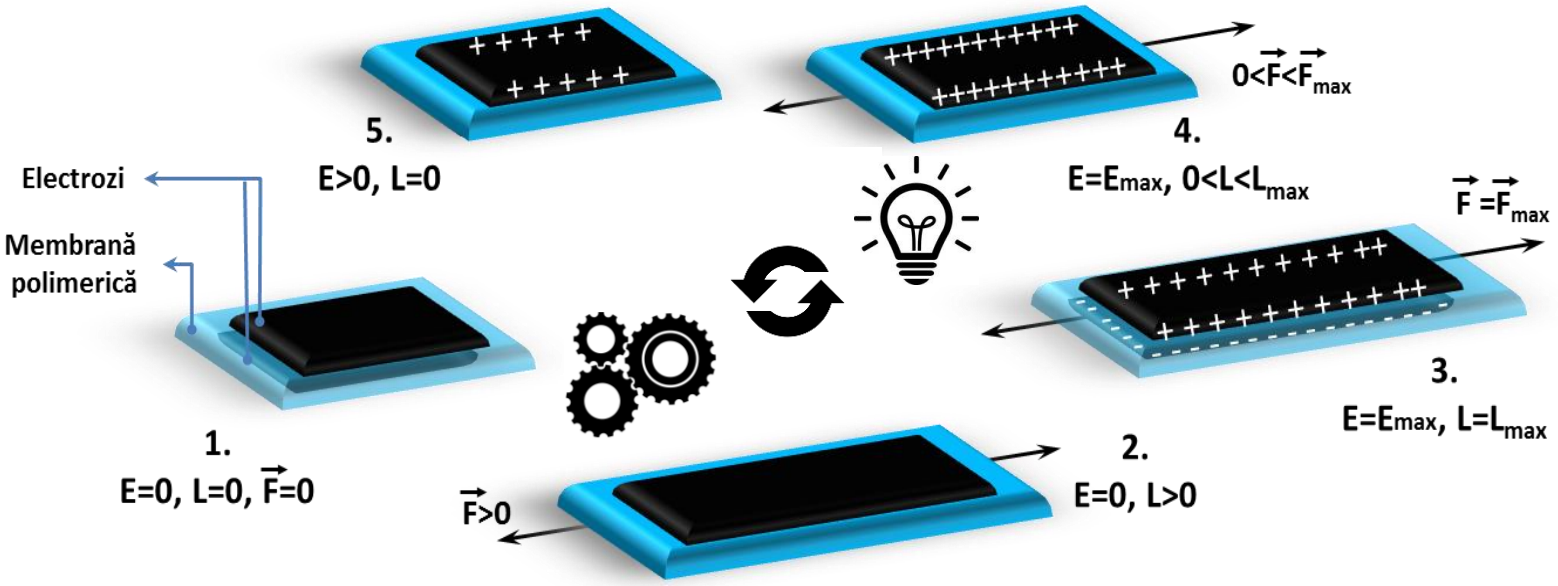
# GreENergy

## Energy harvesting structures optimized through green silicone chemistry

**Contractor:** "Petru Poni" Institute of Macromolecular Chemistry
**Project type:** experimental demonstrative, PN-III-P2-2.1-PED
**Contract number:** PN-III-P2-2.1-PED-2016-0188/CNCS/CCCDI-UEFISCDI (Grant 68PED/2017)
**Implementation period:** 1.01.2017-30.06.2018
**Project budget:** 600 000 lei
**Project leader:** Dr. Maria Cazacu

# GreEnergy - *Scop*

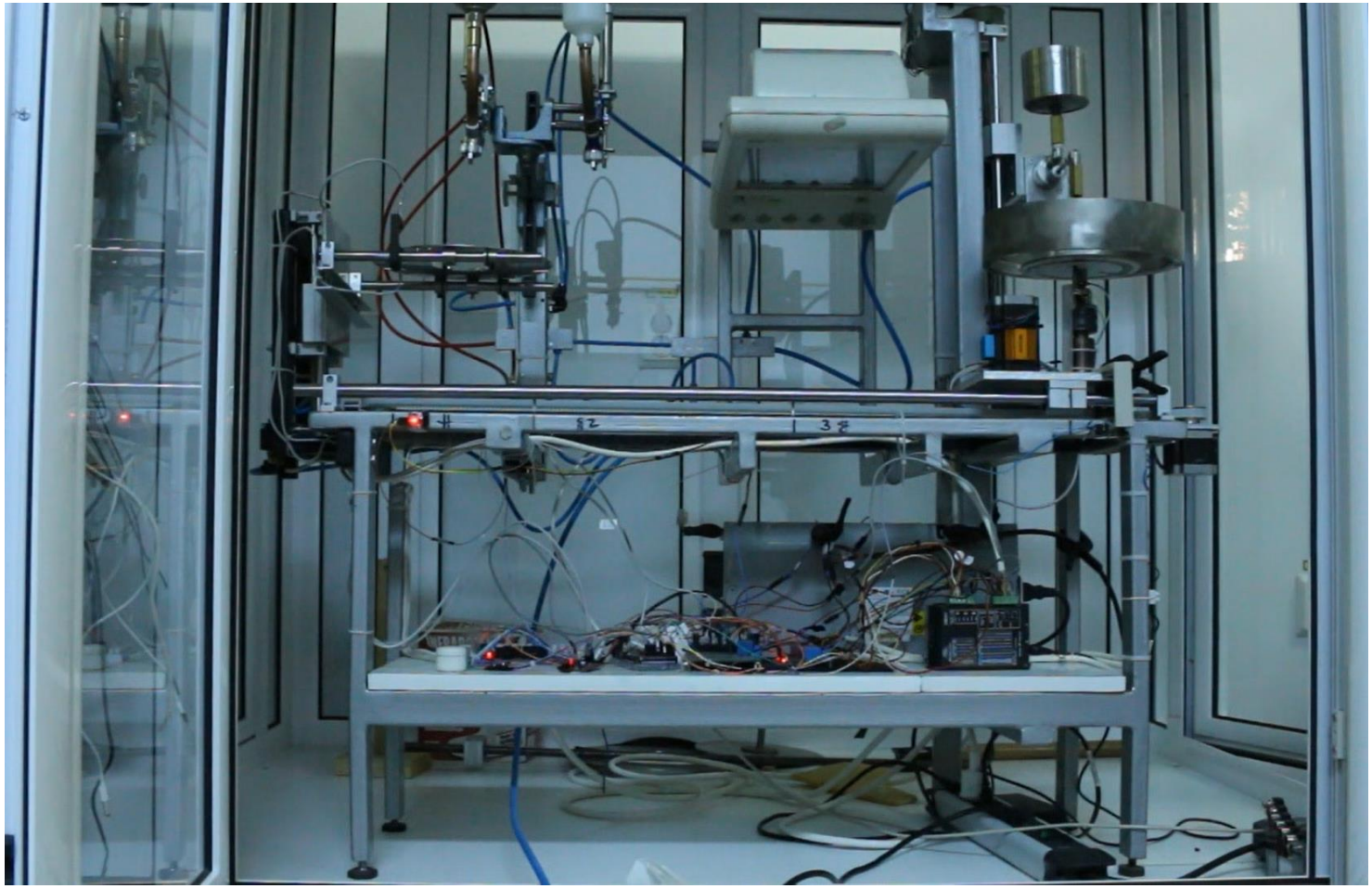
**Scopul** proiectului este de a dezvolta, printr-o abordare relativ "verde", o tehnologie de laborator pentru obtinerea de elemente active capabile sa transforme eficient energia mecanica in energie electrica. Acestea se bazeaza pe filme de elastomeri dielectrici (DE), acoperite pe ambele parti cu electrozi complianti, care formeaza un un capacitor sau un generator - DEG.




Proiectul raspunde la una din marile provocari cu care se confrunta societatea privind sursele de energie eficiente, curate si sigure. Elastomerii dielectrici (ED) s-au evidentiat ca materiale promitatoare pentru conversia de energie oferind numeroase avantaje fata de alte tehnologii prin eficienta ridicata in generarea de energie (alungire si densitate de energie ridicata) si proprietati de material mai bune (cost scazut, complianta ridicata, durabilitate si toleranta la mediul inconjurator).

# GreEnergy - *Scop*

Proiectul va furniza o tehnologie de laborator capabila sa produca elemente de recoltare de energie ajustabile in functie de cerinte, formate din straturi flexibile alternante de dielectric/electrod bazate pe diferite combinatii de siliconi.



# GreEnergy - *Etape, activitati si livrabile asociate*

| Etapa 1: Proiectarea si optimizarea elastomerului dielectric si a electrodului | |
|---|---|
| **Activitati** | **Rezultate asteptate** |
| A1.1.Optimizarea structurii si compozitiei materialului dielectric | ●Cel putin patru polimeri siloxanici de mase moleculare prestabilite<br>●Cel putin doi polisiloxani modificati cu grupe polare<br>●Cel putin un material de umplutura, si anume nanotuburi de $TiO_2$<br>●Filme dielectrice de diferite marimi<br>●Fisa cu specificatii tehnice pentru filme dielectrice<br>●Filme de electrod<br>●Fisa cu specificatii tehnice pentru filme de electrod<br>●Elemente pentru unitati de conversie a energiei<br>●Fisa cu specificatii tehnice pentru elemente de conversie a energiei<br>●Doua articole stiintifice trimise la publicat |
| A1.2. Prepararea de materiale de umplutura | |
| A1.3. Optimizarea procesului de formare si reticulare a filmului dielectric si a geometriei acestuia | |
| A1.4. Evaluarea comportarii mecanice si dielectrice a filmelor dielectrice preparate | |
| A1.5. Optimizarea structurii si compozitiei electrodului | |
| A1.6. Caracterizarea electrozilor sub forma de filme de sine statatoare | |
| A1.7. Optimizarea procesului de depunere a electrodului pe dielectric | |
| A1.8. Evaluarea comportarii mecanice si electrice a ansamblului dielectric-electrod | |
| A1.9. Diseminarea rezultatelor stiintifice: participare la manifestari stiintifice, redactare si publicare de lucrari stiintifice | |

| Etapa 2: Validarea in laborator a demonstratorului experimental de laborator | |
|---|---|
| **Activitati** | **Rezultate asteptate** |
| A2.1. Stabilirea configuratiei si punerea in functiune a instalatiei pentru depunerea succesiva de filme de elastomeri dielectrici si electrozi complianti si demonstrare | ●Instalatie de laborator pentru producerea de elemente pentru unitati de conversie a energiei<br>●Echipament de laborator configurat pentru teste de recoltare a energiei<br>●Un articol stiintific trimis la publicat |
| A2.2. Up-gradarea si realizarea configuratiei necesare a instalatiei de evaluare a capacitatii de conversie de energie a unitatilor obtinute | |
| A2.3. Demonstrarea functionalitatii metodei/procedurii | |
| A2.4. Diseminarea rezultatelor stiintifice: Participare la manifestari stiintifice, redactare si publicare de lucrari stiintifice | |

# GreEnergy – *Rezultate stiintifice*

## Articole publicate

1. The effects of incorporating fluorinated polyhedral oligomeric silsesquioxane, [F3C(CH2)2SiO1.5]*n* on the properties of the silicones, M. Iacob, A. Bele, A. Airinei, M. Cazacu, *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 522, 66-73 (2017), DOI:10.1016/j.colsurfa.2017.02.045. *WOS:000404491600008; JUN 5 2017; IF: 2,714; SRI: 0.561*
2. All-silicone elastic composites with counter –intuitive piezoelectric response, designed for electromechanical applications, C. Racles, M. Dascalu, A. Bele, V. Tiron, M. Asandulesa, C. Tugui, A. Vasiliu and M. Cazacu, *J. Mater. Chem. C*, 5, 6997-7010, (2017), DOI: 10.1039/C7TC02201H.*WOS:000406107600012; JUL 28 2017; IF: 5.256; SRI: 1.104*
3. Iron oxide nanoparticles as dielectric and piezoelectric enhancers for silicone elastomers, M. Iacob, C. Tugui, V. Tiron, A. Bele, S. Vlad, T. Vasiliu, M. Cazacu, A. L. Vasiliu, C. Racles. Smart Materials and Structures, 26, 105046 (2017), DOI: 10.1088/1361-665X/aa867c.*WOS:000411444100003; OCT 1 2017; IF: 2.909; SRI: 0.767*
4. Stretchable energy harvesting devices: attempts to produce high-performance electrodes; C. Tugui; C. Ursu; L. Sacarescu; M. Asandulesa; G. Stoian; G. Ababei, M. Cazacu; ACS Sustainable Chemistry & Engeering, 5, 7851-7858 (2017), DOI: 10.1021/acssuschemeng.7b01354.*WOS:000410006200045; SEP 1 2017; IF: 5.951; SRI: 1.181*
5. Assessment of chemicals released in the marine environment by dielectric elastomers useful as active elements in wave energy harvesters, M. Zaltariov, A. Bele, L. Vasiliu, L. Gradinaru, N. Vornicu, C. Racles, M. Cazacu, J. Haz. Mat. 341, 390-403, (2018), DOI: 10.1016/j.jhazmat.2017.07.068. *WOS:000412378700043; JAN 5 2018; IF: 6.065; SRI: 1.173*

# GreEnergy - *Rezultate stiintifice*

6. Ceramic nanotubes-based elastomer composites for applications in electromechanical transducers, A. Bele, C. Tugui, L. Sacarescu, M. Iacob, G. Stiubianu, M. Dascalu, C. Racles, M. Cazacu, Mater. Design., 141, 120 – 131, (2018), DOI: 10.1016/j.matdes.2017.12.039, *DEC 20 2017; IF: 4.36; SRI: 2.065.*

## Brevete de inventie

1. C. Racles, M. Cazacu, *Procedeu de obtinere a siliconilor colorati transparenti,* OSIM 01085 / 11.12.2017;
2. A. Bele, M. Cazacu, M. Neagu, M. Popescu, C. Racles, *Instalatie modulara si procedeu pentru obtinerea generatoarelor polimerice stratificate*, OSIM A/00127 / 26.02.2018.

## Lucrari publicate in extenso in volume de manifestari stiintifice

1. Codrin Tugui, Mihaela Dascalu, Maria Cazacu, Materiale siliconice pentru energie: performante si limite, Stiinta Moderna si Energia, Editia a XXXVI-a, 17-18 mai 2018, Cluj-Napoca.

## Prezentari orale

1. Silicone-based materials for electromechanical applications; A. Bele, M. Dascalu, C. Racles, M. Cazacu; 11th International Workshop on Silicone Polymers 2-6 iulie 2017, Snekkersten, Denmark.

2.Iron oxide nanoparticles for energy conversion devices; M. Iacob; Stiinta Moderna si Energia Editia a XXXV-a, 18-19 mai 2017, Cluj-Napoca;

3. Maria Cazacu, Materiale siliconice pentru energie: performante si limite, Stiinta Moderna si Energia, Editia a XXXVI-a, 17-18 mai 2018, Cluj-Napoca – comunicare in plen;

4. Mihaela Dascalu, Abordari pentru cresterea performantei electromecanice a elastomerilor siliconici, Stiinta Moderna si Energia, Editia XXXVI-a, 17-18 mai 2018, Cluj-Napoca – comunicare in plen.

# GreEnergy - *Rezultate stiintifice*

## Stagii stiintifice

1. Adrian Bele, EuroEAP - Scientific mission grand (SMG): Green silicone based interpenetrating polymer networks as dielectric elastomers for electro-mechanical applications. Department: Danish Polymer Center, Technical University of Denmark, Copenhagen, Denmark, 27.06.2017
- 12.08.2017.

## Postere la manifestari stiintifice

1. Maria Cazacu, Codrin Tugui, Bele Adrian, Elena Hamciuc, Polysiloxane-polyimide semi-interpenetrated networks with dual electromechanical response, EuroEAP 2017: 7th International conference on Electromechanically Active Polymer (EAP) transducers & artificial muscles, 6-7 June **2017**, Cartagena, Spain;
2. Codrin Tugui, Maria Cazacu; Comparative approaches to high performance stretchable electrodes, EuroEAP 2017: 7th International conference on Electromechanically Active Polymer (EAP) transducers & artificial muscles, 6-7 June **2017**, Cartagena, Spain.
3. Adrian Bele, Codrin Tugui, Mihaela Dascalu, Carmen Racles, Maria Cazacu, Functionalized silicones showing giant actuation strains, EuroEAP 2017: 7th International conference on Electromechanically Active Polymer (EAP) transducers & artificial muscles, 6-7 June **2017**, Cartagena, Spain.
4. Mihail Iacob, Maria Cazacu, Tudor Vasili, Carmen Racles, Iron oxide nanoparticles as fillers for silicone elastomers to improve their dielectric permittivity and induce piezoelectric effect; EuroEAP 2017: 7th International conference on Electromechanically Active Polymer (EAP) transducers & artificial muscles, 6-7 June **2017**, Cartagena, Spain.

# GreEnergy - *Rezultate stiintifice*

5. Adrian Bele, Lyiun Yu, Maria Cazacu, Carmen Racles, Anne Skov, Binary silicone elastomeric systems with stepwise crosslinking as a tool for tuning electromechanical behaviour, EuroEAP 2018: 8th International conference on Electromechanically Active Polymer (EAP) transducers & artificial muscles, 5-6 June **2018** Lyon, France;
6. Codrin Tugui, Maria Cazacu, Assembling and comparative evaluation of stacked actuators based on different active elements, EuroEAP 2018: 8th International conference on Electromechanically Active Polymer (EAP) transducers & artificial muscles, 5-6 June **2018**, Lyon, France;
7. Mihail Iacob, Vasile Tiron, Codrin Tugui, Mihaela Dascalu, Maria Cazacu, Natural sodium bentonite - a filler with unexpected effects on silicones, EuroEAP 2018: 8th International conference on Electromechanically Active Polymer (EAP) transducers & artificial muscles, 5-6 June **2018**, Lyon, France;
8. Mihaela Dascalu, Mihail Iacob, Codrin Tugui, Adrian Bele, Carmen Racles, Maria Cazacu, An attempt to improve the performance of silicone dielectric elastomers through the filling strategy, EuroEAP 2018: 8th International conference on Electromechanically Active Polymer (EAP) transducers & artificial muscles, 5-6 June **2018**, Lyon, France;
9. Carmen Racles, Mihaela Dascalu, Adrian Bele, Codrin Tugui, Maria Cazacu, Polysiloxanes modified with Disperse Red 1 forming stimuli responsive free-standing thin film, EuroEAP 2018: 8th International conference on Electromechanically Active Polymer (EAP) transducers & artificial muscles, 5-6 June **2018**, Lyon, France;
10. Adrian Bele, Maria Cazacu, Marian Neagu, Mircea Popescu, Carmen Racles, Ghiocel Emil Ioanid, Instalatie modulara si procedeu pentru obtinerea generatoarelor polimerice stratificate, The 22nd International Exhibition of Inventics “INVENTICA 2018”, 27 –29 June **2018**, Iasi – Romania.

# GreEnergy - *Rezultate stiintifice*

## Teze de doctorat

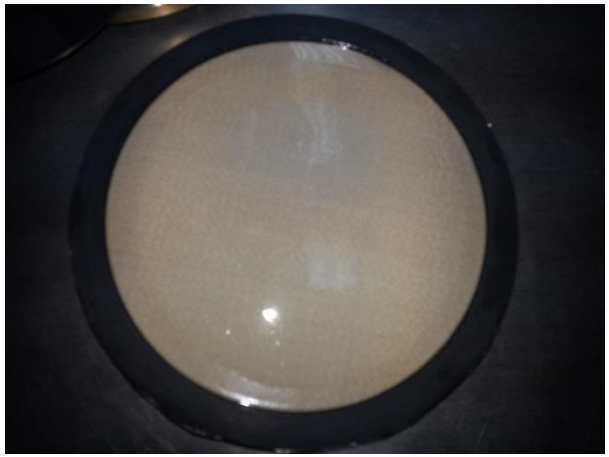
1. TUGUI Codrin, Retele polimerice interpenetrate electro-active continand siliconi, 21.07.2017. Teza este dedicata cuplarii in retele interpenetrate a polisiloxanilor cu alti parteneri siliconici sau organici pentru dezvoltarea de proprietati electromecanice performante cu electrozi adecvati.

2. BELE Adrian, Materiale siliconice inteligente, 25.10.2017. Teza abordeaza siliconii din perspectiva capacitatii lor de a raspunde la stimuli electrici si mecanici, axandu-se pe modificarea chimica a acestora pentru a le spori performantele electromecanice.

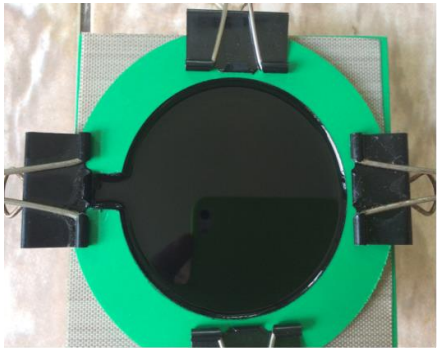
# GreEnergy - *Rezultate stiintifice*

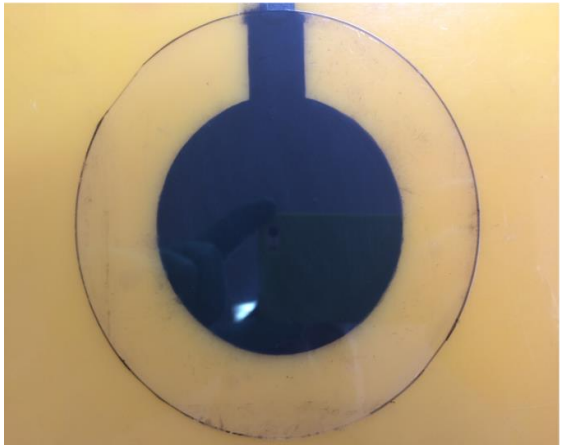
## Imagini ale elementelor unui generator polimeric obtinut in etapele proiectului

- **Filme dielectrice (activitatea A1.3)**



- **Filme de electrod (activitatea A1.5 si A1.6).**





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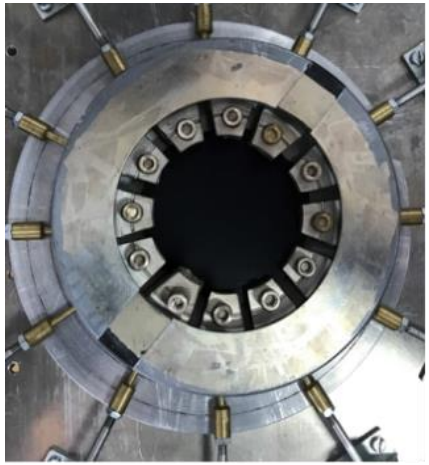
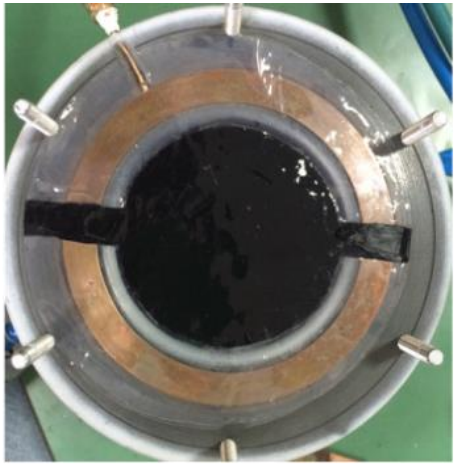
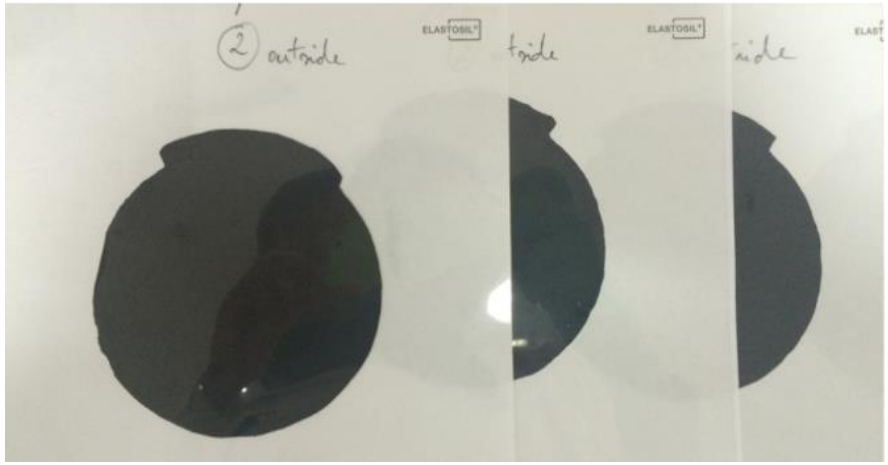
## Imagini ale unitatilor de conversie obtinute in etapele proiectului

- **Unitati de conversie obtinute in activitatea A1.7**






# GreEnergy – *Echipa proiectului*

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Drd. Adrian Bele

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**Membru in echipa**
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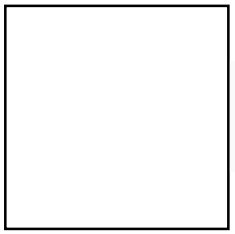
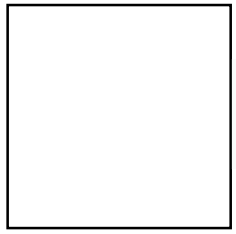
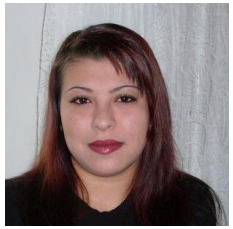


**Inginer mecanic**
Mircea Popescu



**Inginer electric**
Alin Negau



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