2023 年臺灣國際科學展覽會
優勝作品專輯

作品編號　030034

參展科別　化學

作品名稱　Laying waste to Energy problems

得獎獎項　三等獎

國　　家　Italy

就讀學校　IIS Galilei Jesi

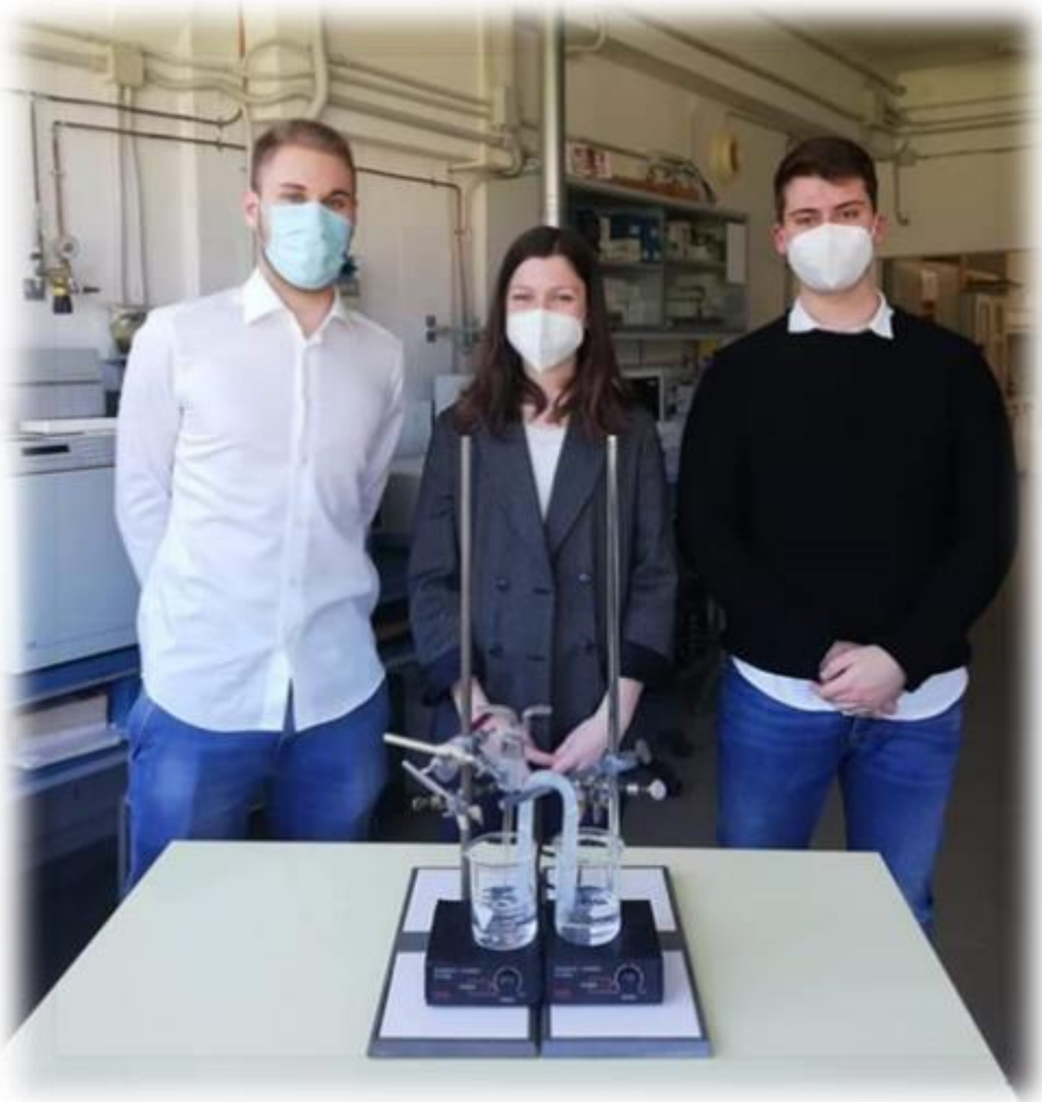
指導教師　Luigi Frati

作者姓名　Leonardo Cerioni

Linda Paolinelli

關鍵詞　Energy、Environment、Water

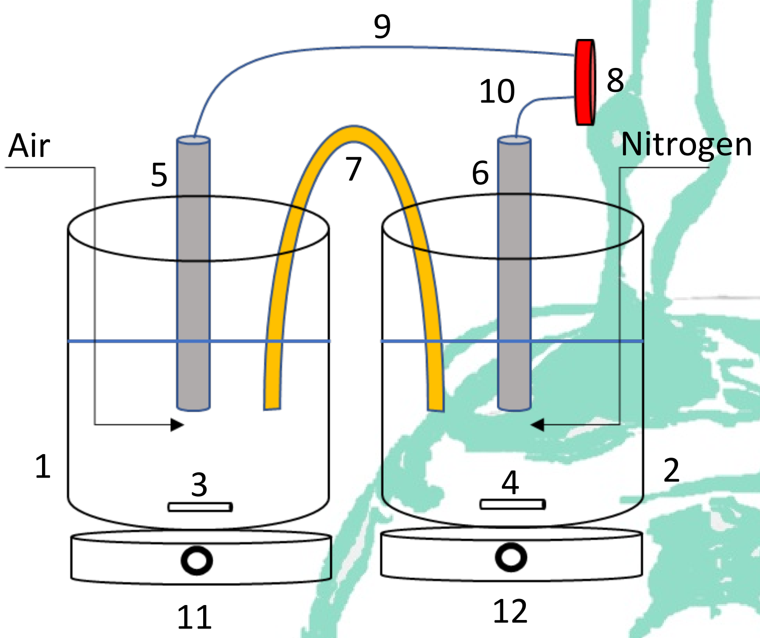
作者照片



Leonardo Cerioni, Linda Paolinelli,
Matteo Santoni with the aid of
Filippo Pieretti

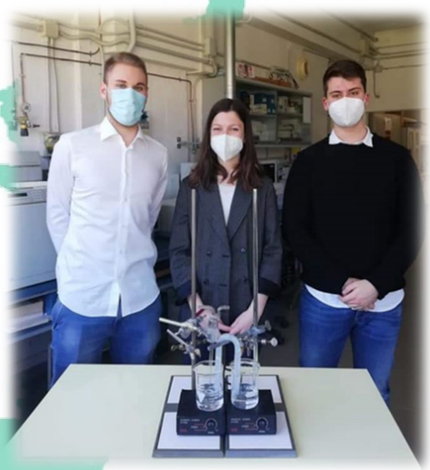
LAYING WASTE TO ENERGY PROBLEMS

THE AVANTGARDE OF ENERGETIC SELF-SUFFICIENCY



Key:
1, 2 → 250 mL beaker
3, 4 → magnetic anchors
5, 6 → graphite electrodes
7 → salt bridge
8 → voltmeter
9, 10 → electric wires
11, 12 → magnetic stirrers

This research aims at exploiting civil and pre-treated industrial wastewaters that go into the purifier and those that come out of it after various treatments in order to build a galvanic cell with the goal of producing clean electric energy.



Our background hypothesis is that it is possible to exploit the existing potential difference between these two types of water to generate electricity. In fact, the water sent for purification contains elements (carbon, nitrogen, sulphur, phosphorus, etc.) in a predominantly "**reduced**" state and its oxygen level is scarce. On the other hand, the water coming out of the process contains the same elements in a mostly "**oxidized**" state and it is rich in oxygen. Those chemical discrepancies should get the job done. In order to simulate the two types of water, two different solutions were prepared. The first one is highly concentrated with pollutants and gaseous **nitrogen** is insufflated in it to reproduce its anoxic environment. The second one's pollution level is based on the Italian legislative limits of chemical contaminants for superficial waters (Legislative Decree 152/2006) and the semi-cell is insufflated with gaseous **oxygen**.

Parameters (molecular or ionic form)	Limits for superficial waters [mg/L]	Pre-depuration solution [mg/L]	Post-depuration solution [mg/L]
Ammonia nitrogen (as NH_4^+)	15	120	15
Nitrous nitrogen (NO_2^- as N)	0.6	4.8	0.6
Nitric nitrogen (NO_3^- as N)	20	160	20
Sulphides (as H_2S)	1	8	1
Sulphites (as SO_3^{2-})	1	8	1
Sulphates (as SO_4^{2-})	1000	500	31.25
Phosphates (PO_4^{3-} as P)	10	40	2.50
Chlorides (as Cl^-)	1200	1000	62.50

Five different experiments have been carried out, each time varying the operating conditions. The two semi-cells' polarity was established with the aid of a battery: the oxygen-rich semi-cell is the **positive pole** (anode), the oxygen-poor one is the **negative pole** (cathode). The polarities happen to be the opposite at different pH values as a result of different possible reactions, which have been hypothesized for each operating condition following the experimental work.

EXPERIMENTS RESUME CHART

Experiment n.	**1**	**2**	**3**	**4**	**5**
pH of the O_2-rich solution	-	7.28	9.07	4.91	7.53
pH of the O_2-poor solution	-	7.44	9.06	4.99	6.40
Polarity of the O_2-rich semi-cell	positive	positive	negative	negative	negative
Polarity of the O_2-poor semi-cell	negative	negative	positive	positive	positive
Potential difference	-	49-50 mV	72-78 mV	75-78 mV	140 mV

Possible reactions in ALKALINE ENVIRONMENT

$$3O_2 + 2H_2S_{(aq)} + 4OH^- \leftrightarrows 4H_2O + 2[SO_3]^{2-}$$

$\Delta E° = 0.918\ V$

$$2[SO_3]^{2-} + O_2 \leftrightarrows 2[SO_4]^{2-}$$

$\Delta E° = 1.331\ V$

Possible reactions in ACID ENVIRONMENT

*Reaction with aqueous H_2S (**aq**)*

$$^1/_2\ O_2 + H_2S_{(aq)} \leftrightarrows H_2O + S_{(s)}$$

$\Delta E° = 1.0851\ V$

*Reaction with gaseous H_2S (**g**)*

$$^1/_2\ O_2 + H_2S_{(g)} \leftrightarrows H_2O + S_{(s)}$$

$\Delta E° = 1.0551\ V$

DISCUSSION

The experiments have shown that it is possible to exploit the chemical species' different oxidation states and their diverse oxygenation conditions before and after the purification process through a galvanic cell in order to produce electric power. The generated potential difference in the experiments is relatively low (ranging from a minimum of 50 mV to a maximum of 140 mV). Nonetheless, by implementing a higher number of systems along the lines of the studied ones, but eventually upgraded (for instance increasing the electrodes' surface or enhancing gas distribution), a rise in such values may well be bound to occur, making it possible to employ our technology for application purposes in the industrial realm. The ultimate goal is to grant the energetic self-sufficiency of the purification plant and other energy-consuming utilities, resulting in a considerable asset both from an environmental and from an economical standpoint.

CONTACT US!

Leonardo: +39 3314664456 leonardo.cerioni@mail.polimi.it
Matteo: +39 3808663759 santonimatteo02@gmail.com
Linda: +39 3333697289 paolinda2510@gmail.com
Filippo: +39 3277339012 filippo.pieretti70@gmail.com

【評語】030034

This is an interesting project because the idea is very innovative. The students explore the possibility to create electricity at the junction of polluted and clean waters. This could affect the future of water-cleaning facilities to be more energy-saving.