Electrochemical techniques combined with UV irradiation for the treatment and reuse of textile dyeing wastewaters: Industrial marketing

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The Problem

Water scarcity has become nowadays a very important concern due to the increasing demand of water and the limited access to the water resources of the Earth. Thus, the reduction of water consumption and its appropriate management are currently greater society challenges.

In the last decades, the problem of water scarcity has led governments to create new environmental policies focused on minimizing the water consumption. In this way, recycling and reusing water contribute to the reduction of water consumption.

However, conventional wastewater treatments are inefficient in eliminating salts and poorly biodegradable organic compounds, which prevents water reuse. For this reason, huge efforts are been made to improve the current wastewater treatments and specially to make them more efficient in reusing water.

ECUVal is a new eco-friendly proposal that aims to contribute both to improve the wastewater treatment and to enable the reuse of the treated effluents, which results in significant savings in water and salts.

ECUVal takes advantage of the salts already contained in the effluents. It does not require the addition of chemical reagents and it does not generate wastes. There is no other recycling-treatment that provides all these advantages.

The ECUVal project promotes a green business and ensures continuing innovation in relation to our environment and nature around us.
ECUVal is a green technology combining an electrochemical process with ultraviolet irradiation to remove organic pollutants from wastewaters.

Unlike other techniques, the ECUVal system does not require the addition of chemical reagents and no wastes are produced, as the pollutants are removed only by applying an electric power.

ECUVal is especially suitable for the treatment of saline effluents containing poorly biodegradable compounds.

The treatment starts with the electro-chemical generation of oxidants in situ from the salts contained in the effluent. These oxidants are very active and break down the organic pollutant molecules into smaller ones. The level of the molecule fragmentation depends on the extent of the treatment.

A subsequent irradiation with a UV light source increases the efficiency of the treatment and also removes all residual oxidants.

The ECUVal system also offers the possibility of reconstituting the effluent for its reuse, once it has been purified. The reconstitution process consists in removing the compounds that can cause any interference in case of reuse. It is carried out by further UV irradiation and/or dosage of some appropriate reagents, depending on the characteristics of water required in the process.

The reuse of the treated effluent implies a reduction in the consumption of water and other chemicals that could be recycled in the process, such as salts, which implies a lower process cost. Also, the reduction of effluent salinity and wastewater discharge rates results in lower taxes.

The main objective of the ECUVal project is to introduce into the market an innovative eco-friendly technology for the treatment of industrial wastewater that provides an effluent able to be reused.

Unlike other existing technologies, this new green proposal aims to achieve the following specific objectives:

- Reduction of water consumption thanks to the reuse of industrial wastewater: recycling 70-100% process water
- Reduction of wastewater salinity due to the treatment and reuse of saline effluents: recycling up to 100% salt in the industrial processes.
- Removal of poorly biodegradable compounds, resistant to conventional treatments: in the case of dyes, up to 100% colour removal.
- Wastewater purification without the addition of chemical reagents.
- Green technology that does not produce wastes.
- Flexible system, operating at smooth conditions.
- High durability, minimal maintenance.
- Sustainable industrial processes: reduction of carbon footprint and environmental impact.
ECUVal is a flexible method that can be applied to a large number of industries: cosmetics, tanning, pharmaceutical, canning, textiles and more.

The textile industry has led the way in applying the first ECUVal industrial prototype in response to the large quantities of wastewater produced by the dyeing process.

In general, textile wastewater contains different kinds of residual dyes and chemical additives, which are poorly biodegradable and cannot be removed in the biological treatment plants.

Most of textile effluents also have high conductivity due to the salts added during the dyeing process to fix dyes onto the fibre. ECUVal is a UV-assisted electrochemical process that uses these residual salts as an electrolyte to generate oxidants in the cells, thus destroying the dye molecules.
In the textile industry, ECUVAl is especially efficient for the treatment of effluents with high colouration and high conductivity values, such as the exhausted dyebaths and washing effluents from the reactive dyeing process.

After the ECUVAl treatment, uncoloured solutions are obtained and no wastes are generated. The uncoloured effluents can be either discharged to a conventional biological plant or reused after a reconstitution step.

**Decolouration function**

The exhausted dyeing liquors and washing baths are segregated to be decolourised by means of the ECUVAl system. Then, the uncoloured effluents are discharged to the wastewater treatment plant in order to achieve the full elimination of the residual organic matter. In this case, the ECUVAl treatment constitutes an alternative to the current tertiary methods used for colour removal.

**Reuse function**

ECUVAl is fitted with a system to treat clarified effluents for reuse. The reuse function is used for the reconstitution of the clarified effluents before being reused.

With this purpose, a number of sensors and pumps are started up to obtain water suitable for reusing in the dyeing process.

The UV irradiation is also initiated to enhance the process efficiency.

The reconstitution is carried out in the following steps:

- Removal of carbonate and bicarbonate by adding acid and subsequent stripping.
- Neutralization of the effluent by adding alkali.
- Removal of residual oxidants by UV irradiation and addition of a reducing agent.

Thus, with the ECUVAl system the effluent can be treated in two modes:

- Decolouration for discharge
- Decolouration + reconstitution for reuse
**ECUVal** has demonstrated to be a flexible and versatile proposal that provide excellent results both for colour removal and for reuse purposes.

By applying an electric current, oxidants are produced from the residual salts. The generated oxidants are used to break down the dye molecules, thus clarifying the wastewater. The level of decolouration can be fixed on the bases of the applied current intensity. The conductivity of the effluent plays also an important role. The higher the intensity and the conductivity, the higher the amount of generated oxidants and consequently, the more efficient the decolouration rate.

The clarified effluents still contain high levels of salts and, at this point they can be sent to a conventional treatment plant or reused in a further dyeing process.

A final ultraviolet irradiation contributes to further reduce any residual colour and to eliminate residual oxidants in order to ensure high quality dyeing results in case of reuse.

Examples of exhausted reactive dyebaths from jet processes treated with the ECUVal system.

**RESULTS**

ECUVal solves the problem of effluent colouration and enables the reuse of water and salts in new dyeing processes with a low energy consumption.

**THE BENEFITS**

From the environmental point of view, the treatment of industrial wastewater with the ECUVal system provides 30% reduction of environmental impact with respect to current technologies:

- **Saving up to 100% water**
- **Saving 70-100% salt**
- **21% reduction of carbon footprint**
- Less chemicals in the wastewater treatment
- Less cost in wastewater treatment
- Less cost in salt
- Less cost in water
- Less cost in taxes
- Almost no maintenance

**Environmental impacts**

As a result, the following socio-economic impacts are associated to the ECUVal technology:

- Less cost in water
- Less cost in salt
- Less cost in taxes
- Almost no maintenance

**Socio-Economic impacts**

**Comparison of dyeings**

Reference: decalcified tap water
Reused: ECUVal treated water (70%)
ECUVal does not require the addition of chemicals and does not generate wastes, which are important environmental advantages respect to the current methods for the decolouration of wastewater. Also, up to 100% of salt is recovered and recycled in a new dyeing process. Thus, the reuse of salt is another important advantage of ECUVal since the current methods employed to remove salts from effluents (mainly reverse osmosis membranes) are expensive and also show operational difficulties. In addition, the ECUVal system enables to recycle the total exhausted dyeing baths, which reduces up to 70% water consumption due to the cyclic process.

**LIFE CYCLE ASSESSMENT**

The life cycle assessment has been studied for the textile sector. Three scenarios were considered:

**A. CURRENT PROCESS**

Effluents are generally discharged to be treated in a biological plant followed by a tertiary treatment to remove colour. The current dyeing process and wastewater treatment have a high impact on human toxicity, especially due to the salt and carbonate consumption in the dyeing process.

**B. ECUVAL PROCESS to decolourise**

The dyeing effluents are previously segregated and decoloured. Subsequently, the decoloured effluents are discharged to the biological plant in order to remove the residuals organic matter. In this case, the environmental impact decreases in 5% with respect to the current process.

**C. ECUVAL PROCESS to reuse**

In this process, the effluents are decoloured with ECUVal and reused in new dyings, instead of being discharged. A reconstitution step is necessary before the reuse. This mode is the most sustainable as the environmental impact is reduced in 30% with respect to the current treatment.

### ENVIRONMENTAL BENEFITS

**Comparison of ECUVal with respect to other technologies**

ECUVal is able to treat the more coloured and with high salt content effluents. No chemicals are required to carry out the electrochemical process. The only cost of the ECUVal treatment is the electric power supply. No wastes are generated. As the high coloured effluents are segregated to the ECUVal system, the tertiary treatment for colour removal can be suppressed in the wastewater treatment plant. This results in a significant reduction of reagents and sludge disposal costs.

Discharge taxes are lowered due to the reduction of wastewater salinity. The system does not need maintenance. The electrodes are very stable and can be used over 5-10 years.

- Less cost in water. Savings of 70-100% dyeing water
- Less cost in salt. Savings up to 100% salt are achieved with the reuse.

On the bases of these advantages and the operating costs, the ECUVal investment will be depreciated in 4-5 years.

### ECONOMIC BENEFITS

**Market segmentation of ECUVal with respect to other technologies**

**Low price**

- Low quality

**High price**

- High quality

### Comparison of ECUVal with respect to the current treatment methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Colour removal</th>
<th>Rate</th>
<th>Cost</th>
<th>Other specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active carbon</td>
<td>Very good</td>
<td>Low</td>
<td>High</td>
<td>Regeneration</td>
</tr>
<tr>
<td>Membranes</td>
<td>Good</td>
<td>High</td>
<td>High</td>
<td>Maintenance and cleaning</td>
</tr>
<tr>
<td>Ozonization</td>
<td>Good</td>
<td>Medium</td>
<td>Very high</td>
<td>By-products</td>
</tr>
<tr>
<td>Coagulation–floculation</td>
<td>Good</td>
<td>Medium–High</td>
<td>Medium</td>
<td>Sludge generation</td>
</tr>
<tr>
<td>ECUVal</td>
<td>Good</td>
<td>High</td>
<td>Medium</td>
<td>Clean and recycle option</td>
</tr>
</tbody>
</table>
The pulp and paper industry uses large amount of wastewater with a high content of organic matter and solids in suspension. ECUVal can improve the wastewater quality to make the effluent reusable.

The leather industry generates large quantity of deeply coloured wastewater that contains chloride, tannins, chromium, sulphate and organic compounds. ECUVal can be used for the removal of colour and also to reconstitute the effluent for reuse.

The chemical industry has a great impact on the environment. The wastewaters from this industry are generally highly concentrated in inorganic and organic pollutants and can also contain non-biodegradable compounds. ECUVal is specially advantageous to remove poorly biodegradable compounds in saline effluents. In some cases, the reuse of the treated effluent can also be considered.

Cosmetic factories also generate wastewaters with very variable characteristics. In general, it contains suspended hydrophobic materials, surfactants and high amount of organic matter. ECUVal is appropriated to treat the less biodegradable effluents, as complimentary to the biological plant.

The pharmaceutical manufacturing industry produces a very diverse range of wastewaters. ECUVal can solve the problem caused by effluents containing poorly biodegradable compounds, thus increasing the efficiency of the wastewater treatment plant.

The introduction of ECUVal in the European market as an innovative solution for the treatment of industrial wastewater will have clear environmental and economic benefits. From the environmental point of view, this new proposal will reduce the impact in 30% and the carbon footprint and the CO2 emissions in 21% with respect to methods currently used. From the economic aspect, a reduction of up to 100% water process and chemicals consumption can be achieved, as well as a reduction of taxes of wastewater treatment and discharge.

In first term, it should be noted that the implementation of ECUVal as a wastewater treatment will contribute to decrease the pollution of European rivers, which is an important input in terms of ecology and sustainability. This decrease of pollution due to the use of ECUVal will be evident in several aspects. Firstly, ECUVal will be able to convert the poorly biodegradable compounds into small molecules that could be destroyed in the conventional activated sludge biological plants. The destruction of this type of poorly biodegradable compounds, which is highly persistent in the environment, constitutes a notorious benefit of ECUVal with respect to other technologies. Currently, this type of pollutants (such as dyes, drugs, etc…) are precipitated by coagulation-flocculation with resins, concentrated in a sludge which is later dried, transported and incinerated in special plants. Therefore, the removal of all these steps will be highly beneficial to improve the European environment, namely: notorious saving of chemical reagents, lower transport logistic and reduction of incineration emissions.

In addition, ECUVal is fitted with a module to condition the treated wastewater for reuse. The reuse of effluents in the industrial processes will promote the saving of water, one of our most important natural resources. In addition, it will contribute in reducing the salinity of water discharges, as the treated effluents still contain salts. It should be highlighted that nowadays the salinity is mainly a water concern in the Mediterranean countries, where the riverbeds are scarce. An increase of rivers salinity has dramatic impacts on aquatic ecosystems, on irrigation and even on drinking water.

On the other hand, ECUVal is a green business that will also provides economic advantages to all the European countries. Due the different energy and water costs in each EU member, it is expected that ECUVal system will be more economically feasible in those countries where the costs of water supply and wastewater treatment are more expensive.

The ECUVal technology has been licensed to ICOMATEX, a Spanish company specialized in textile machinery that will be responsible for its commercialization. This will potentiate the European textile machinery sector. Moreover, the customers of ICOMATEX are located worldwide which will contribute to increase the European exportations. Thus, ECUVal will be profitable for the EU economy due to foreign countries will buy and invest on European products.

In summary, in relation to the environmental challenges, the ECUVal proposal is addressed mainly to companies that generate effluents with high salinity and low biodegradability. This new technology will reduce the environmental impact associated to the removal the poorly biodegradable compounds from wastewater. ECUVal will also contribute to lower the salinity of European rivers, mainly in the Mediterranean countries. Currently, there is no other wastewater treatment available for this purpose, economically feasible.