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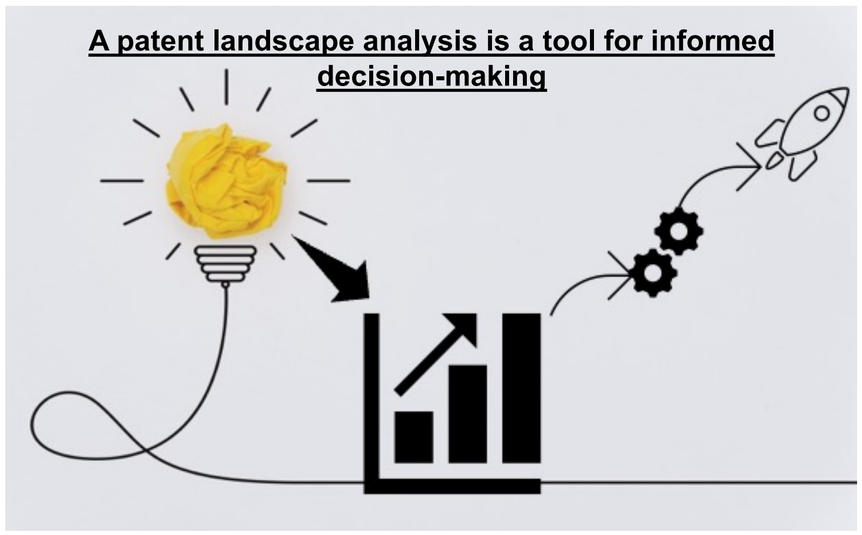
Hydrogen peroxide industrial production: a patent prior art analysis

Massimo Barbieri

Politecnico di Milano (technology Transfer Office), e-mail: massimo.barbieri@polimi.it

INTRODUCTION & AIM

The aim of this study is to present an overview of hydrogen peroxide patented processes.



Hydrogen peroxide is a colourless liquid that is completely miscible in water.
It is industrially produced through a process of reduction and oxidation of an alkylated anthraquinone (AO process), using hydrogen (from steam reforming of methane) and air, with Pd/Al_2O_3 as a catalyst, at a temperature of 45°C. [1]
Various methods can be used to produce the desired product, including direct synthesis from hydrogen and oxygen using a palladium-based catalyst, electrochemical synthesis, photocatalytic production and partial oxidation of primary or secondary alcohols resulting in the formation of aldehydes or ketones as by-products. Another method involves synthesising the product from water, carbon monoxide, and oxygen [2, 3].

METHOD

Patent searches were carried out using two databases:
- **Espacenet** (available at https://worldwide.espacenet.com), a free-of-charge patent database provided by the European Patent Office) and
- Orbit Intelligence (https://www.orbit.com), a fee-based IP software managed by Questel and consisting of three search system: FamPat, FullPat & FullText.

All patent searches were performed on **FamPat** database, using a combination of keywords and classification symbols.

Table 1 provides the complete list of classification codes (IPC and CPC) used in the search queries.
For electrolytic production, where the classification symbol has a broad definition, the keywords ('H_2O_2' and 'hydrogen peroxide') were used in the title, abstract, and claims search fields with a proximity operator.

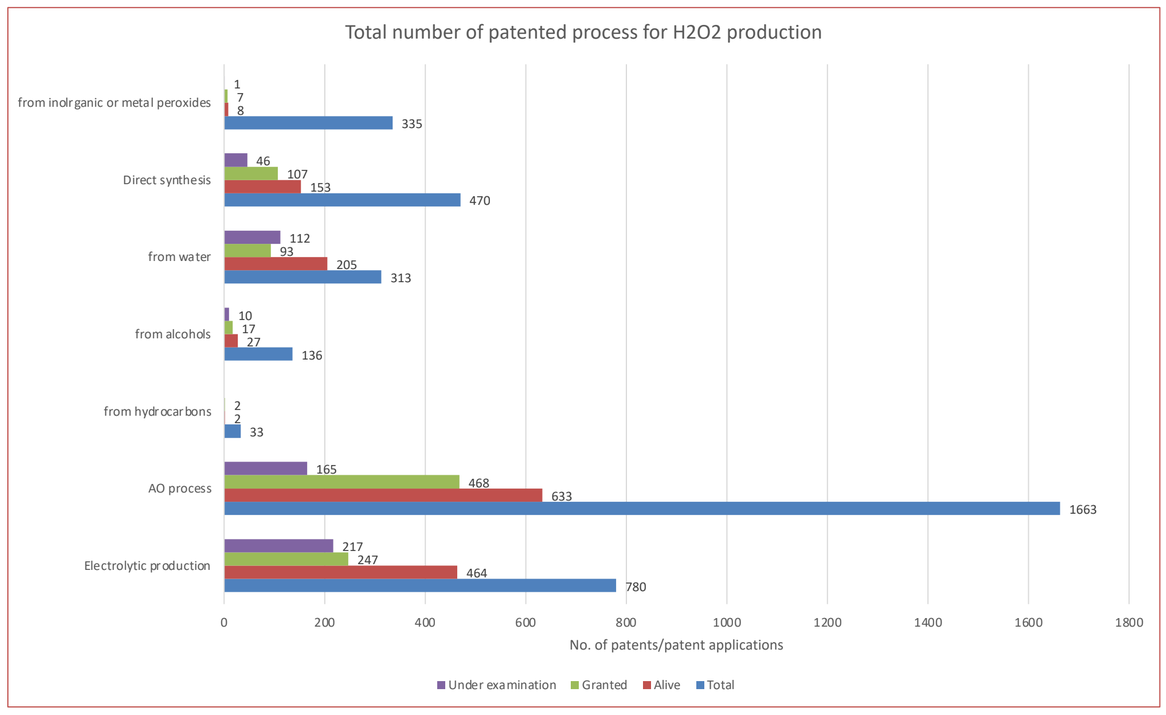
Classification code	System	Definition
C25B 1/30	IPC/CPC	Electrolytic production of peroxides
C01B 15/022	IPC/CPC	Preparation of H_2O_2 from organic compounds
C01B 15/023	IPC/CPC	Preparation of H_2O_2 by the alkyl-anthraquinone process
C01B 15/024	IPC/CPC	Preparation of H_2O_2 from hydrocarbons
C01B 15/026	IPC/CPC	Preparation of H_2O_2 from alcohols
C01B 15/027	IPC/CPC	Preparation of H_2O_2 from water
C01B 15/0275	CPC	Preparation of H_2O_2 from water, carbon monoxide and oxygen
C01B 15/029	IPC/CPC	Preparation of H_2O_2 from hydrogen and oxygen (direct synthesis)
C01B 15/0295	CPC	Preparation of H_2O_2 by electric discharge
C01B 15/03	IPC/CPC	Preparation of H_2O_2 from inorganic peroxides
C01B 15/032	IPC/CPC	Preparation of H_2O_2 from metal peroxides

Table 1. - List of classification symbols used in the patent search

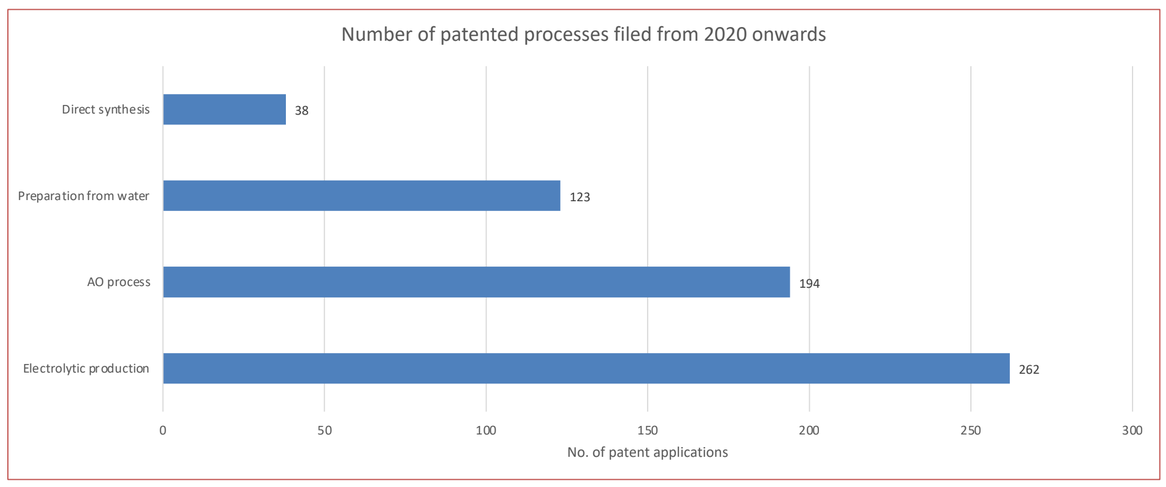
Other classification codes found in Espacenet do not relate to the production of hydrogen peroxide, but rather to its uses.
For example, C02F 1/722 is related to wastewater treatment processes, where contaminants are oxidised by peroxides. These codes were not considered in the research.

RESULTS & DISCUSSION

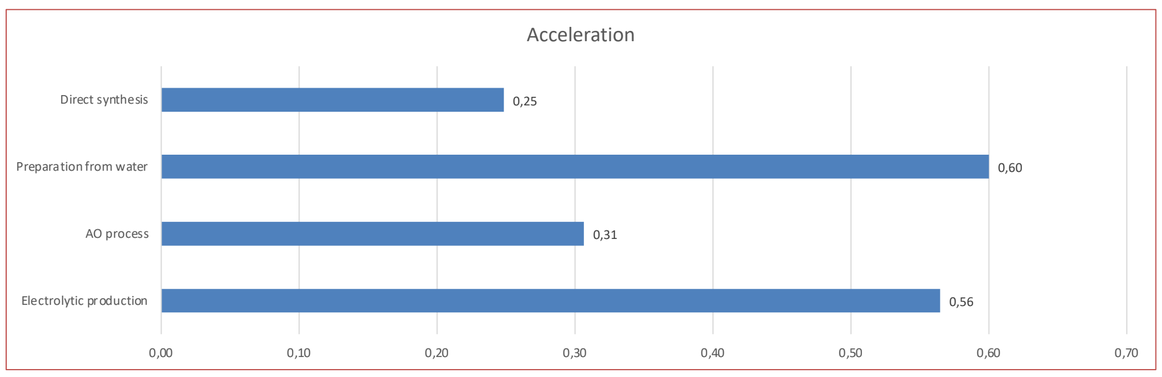
The anthraquinone auto-oxidation process and electrochemical methods have the highest number of active patents.



When examining patent applications filed from 2020 onwards, electrochemical methods are found to be the most prevalent, followed by the auto-oxidation of anthraquinone.



By using the 'acceleration' indicator it is possible to determine which patented technology has experienced the greatest increase in the number of filings over time.



CONCLUSION

The data suggests that companies are investing less in the anthraquinone auto-oxidation process compared to electrochemical methods.
Research is now focused on synthesizing hydrogen peroxide from water by photocatalytic processes instead of direct synthesis using H_2 and O_2.

REFERENCES

[1] R. Ciriminna et al., *ChemSusChem* 2016, **9**, 3374 – 3381
[2] G. Gao et al., *Chinese Journal of Catalysis* 2020, **41**, 1039 – 1047
[3] P. Garcia-Munoz et al., *Topics in Current Chemistry* 2023, **381**, 15, 1 – 73