Environmental Aspects of ECF and TCF Chemical Woodpulp Bleaching

cpi confederation of paper industries

FACT SHEET

This Fact Sheet summarises the environmental impact of the two main methods used for bleaching chemical woodpulp. These methods are Elemental Chlorine Free (ECF) and Total Chlorine Free (TCF). It is not intended as a technical treatise.

Background

Until the early '90s, chlorine gas was used as the main component of the bleaching process for chemical woodpulp. At that time, it was discovered that significant amounts of the dioxin and furan chemical families were being discharged to watercourses by pulp mills and a world-wide movement was begun to implement alternative processes. Initially, the main alternative pursued was the TCF process where oxygen is used to remove the lignin from the pulp and ozone or hydrogen peroxide used to complete the bleaching. Then, gradually, ECF began to emerge as a viable alternative where chlorine dioxide is substituted for the element chlorine in the bleaching cycle. As the ECF process was refined, it eventually became the main method and currently accounts for over 80% of the world production of bleached pulp. Virtually all new pulp mills use this process and some TCF mills have even converted to it.

Definitions / Glossary

Elemental Chlorine (EC) bleaching is the traditional method for bleaching pulp, using chlorine gas (elemental chlorine). This process produces significant amounts of toxic chemical compounds called dioxins and furans.

Elemental Chlorine Free (ECF) bleaching technique uses chlorine dioxide and e.g., hydrogen peroxide as bleaching agents. Oxygen delignification is often used prior to ECF bleaching, as this reduces the amount of bleaching chemicals required.

Process Chlorine Free (PCF) indicates that fibres are recycled and treated/bleached using totally chlorine-free compounds. Recovered fibre cannot be considered totally chlorine free, because the previous bleaching method of the fibres is not known.

Pulp bleaching is the process where wood pulp fibres are chemically treated before papermaking to remove lignin and resins. Pulp bleaching results in white and clean paper products.

Totally chlorine free (TCF) bleaching technique uses oxygen delignification in combination with hydrogen peroxide or ozone as the main bleaching agents.

Environmental Impacts

It is generally recognised that discharges to atmosphere and energy use are not significant environmental issues for either the TCF or ECF process. There are, however, discernible differences in liquid effluent discharges and the quality of the pulp itself. These differences are summarised on Page 2.

Overall, it is accepted that TCF and ECF discharges cannot be separated on environmental grounds. Regarding the pulp itself, the ECF process has the advantage of a significantly higher ratio of finished fibre to wood.

When chlorine bleaching was being phased out, the replacement technologies were largely untried and some of the processes were unstable. Effluent data generated at that time reflected those problems and opinions were formed about the merits of the new situation which have proved incorrect in hindsight. Whilst the processes themselves have become better understood, the greatest progress has been made in effluent plant technology and it is now possible to demonstrate that the discharges to watercourses, from both ECF and TCF, are of no environmental concern.

Best Available Technology (BAT)

BAT has legal status in both the USA and Europe when determining consents for the discharge of effluent. In the USA, the ECF process is regarded as being Best Available Technology and in Europe, the Commission has decided that there is no significant difference between TCF and ECF and, therefore, both are regarded as BAT. The Pulp & Paper BREF 2014 states "The special focus on the question of whether modern ECF or TCF bleaching is better from an environmental perspective seems to be too narrow; the entire mill operation including the wastewater treatment system and the avoidance of disturbances and accidental releases are also crucial aspects to consider. For example, the amounts of fatty acids, resin acids and sterols in the effluent from modern kraft mills are affected more by the fibre raw material or by contributions from the unbleached side than by the bleaching process."

A landmark report on the subject of the best technology was produced for the Tasmanian Resource Planning and Development Commission by a number of leading environmental consultancies in 2006. This analysed a report from WWF in which the relative merits of TCF and ECF were discussed in relation to the Arauco Valdivia ECF pulp mill in Chile. The former report clearly concluded that TCF and ECF effluents could not be separated on environmental grounds. Subsequent reports including a literature review in 2019 confirm the same conclusions.

Sources of Data

A number of documents were used when compiling this paper and the details of some of them are given on Page 3. They should be consulted if more detailed data is required.

Table 1 Effluent Quality and Considerations

	TCF	ECF
AOX (adsorbable organic halides)	none	Some AOX content from bleaching process but substances are different to those produced by chlorine gas and are non-persistent. Modern effluent plants reduce this content to a level which is insignificant.
Molecular weight of compounds in effluent	Low molecular weight compounds such as glyoxal and vanillin	Generally high molecular weight (and therefore less toxic) compounds detected.
Short-term single species toxicity	TCF and ECF equal	TCF and ECF equal
Chronic single species toxicity	Slightly higher but below toxicity level of natural peat bog water and municipal effluent	Slightly lower and below toxicity level of natural peat bog water and municipal effluent
Overall environmental watercourse impact	TCF and ECF equal and both below toxicity level of natural peat bog water and municipal effluent	TCF and ECF equal and below toxicity level of natural peat bog water and municipal effluent
Results of biological tests on effluent of mills having both TCF and ECF plants	TCF and ECF equal	TCF and ECF equal
Endocrine disruption	There is some evidence of endocrine disrupting substances in the effluent of both processes, but these are believed to originate from wood or naturally-occurring chemicals and the impact from the two processes is indistinguishable.	

Table 2 Pulp Considerations

Brightness	Bleaching reduces pulp strength. At the same level of reduction, ECF produces pulp having approximately 2 ISO points brighter than TCF.
Yield (i.e.) how much pulp can be made from the trees	For hardwoods, ECF has an approx. 2% higher yield than TCF and for softwood, this advantage rises to around 4%.

Sources of Data

- Environmental Performance of Modern ECF Bleaching, Axegard & Bergnor https://www.researchgate.net/publication/287042381_Environmental_performance_of_modern_ECF_bleaching
- The effect of the transition from elemental chlorine bleaching to chlorine dioxide bleaching in the pulp industry on the formation of PCDD/Fs, Peter Axegard https://www.sciencedirect.com/science/article/pii/S0045653519316078
- Beca AMEC, 'Review of ECF and TCF bleaching processes and specific issues raised in the WWF report on Arauco Valdivia' https://businessdocbox.com/66592030-Green_Solutions/Study-report-for-review-of-ecf-and-tcf-bleaching-processes-and-specific-issues-raised-in-the-wwf-report-on-arauco-valdivia.html
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- Stora Enso (2017), 'Pulp bleaching Fact Sheet@ https://www.storaenso.com/-/media/documents/download-center/documents/sustainability/pulp_bleaching_fact_sheet_2017.pdf
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