Liquid crystal monomers of emerging concerns: Impacts and mitigation strategies

Liquid crystal monomers pose rising environmental risks. Discover their impact, health concerns, and global efforts to manage and mitigate these effects.

 Sanjeeb Mohapatra · October 10, 2024

Since their discovery by Austrian scientist Friedrich Reinitzer in 1888, liquid crystals have become essential to many industries, especially in making liquid crystal displays (LCDs) used in TVs, computer monitors, and smartphones. This importance was highlighted when Pierre-Gilles de Gennes won the Nobel Prize in Physics in 1991 for his research into how materials like liquid crystals balance order and disorder. However, recent studies suggest these compounds carry environmental risks. This has led scientists and policymakers to examine their effects on ecosystems and explore ways to reduce their impact.

Understanding liquid crystal monomers

Liquid crystal monomers (LCMs) are organic chemicals essential for creating the liquid crystals used in LCDs—found in devices like TVs, computer monitors, and smartphones. The global market for LCDs was valued at approximately USD 142.36 billion in 2022 and is projected to reach around USD 231.75 billion by 2030, growing at an annual rate of 6.28% (Figure 1). LCMs are a critical part of the process that forms liquid crystal materials, but as their use expands, concerns have grown about their potential to linger in the environment and cause harm.

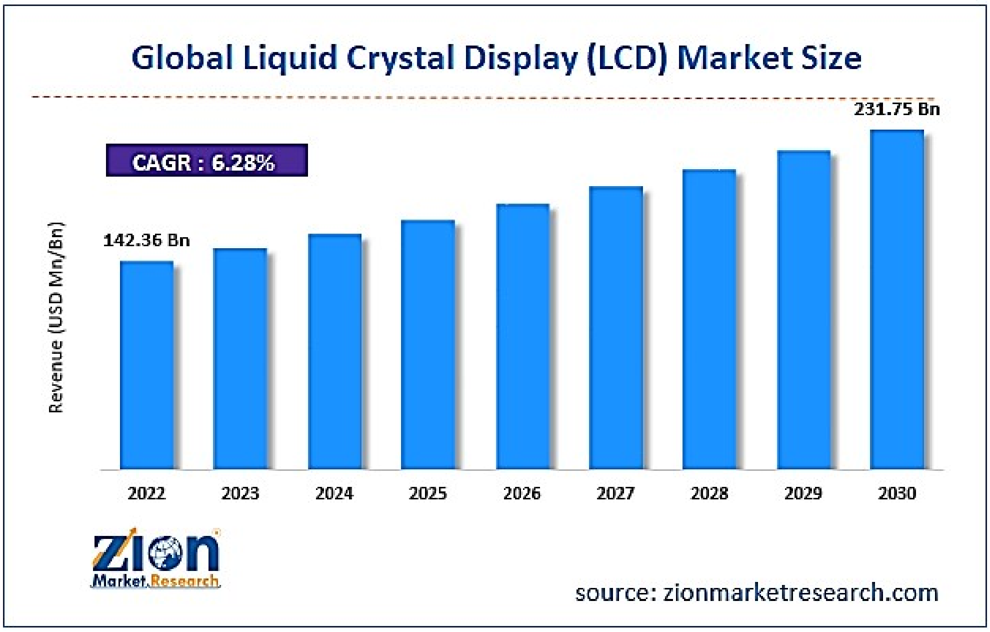

Figure 1. Global LCD market size
Credit. Zion market research

Environmental concerns

Recent research shows that liquid crystal monomers (LCMs) are increasingly found in water sources, especially near manufacturing plants and e-waste dismantling sites. When released into the environment, these compounds can build up in water bodies, eventually accumulating in fish and other aquatic organisms. This accumulation threatens both aquatic ecosystems and human health, as contaminated water can infiltrate the food chain.

Studies from e-waste sites in China have found high levels of LCMs in soil, sediment, and landfill runoff, while limited studies from the U.S. and Sweden detected LCMs in dust. These findings suggest that LCMs may persist in the environment for long periods, raising concerns about their potential to spread into drinking water sources and even reach water treatment facilities.

Hidden health hazards: What we know about LCMs so far

The health effects of LCM exposure are still being studied, but early research suggests these chemicals could interfere with hormone functions, leading to developmental and thyroid issues. Additionally, as LCMs degrade, they may produce toxic byproducts, which raises further safety concerns. While there is growing attention on the health risks of similar chemicals, such as PFAS, LCMs have received far less research focus. However, as public awareness increases, so do calls for comprehensive studies to assess the potential risks of LCMs in drinking water and food sources.

Global disparities in regulation: A call for unified action

Environmental regulations for emerging contaminants like LCMs vary widely across the globe. Europe has implemented strict rules to limit harmful substances, such as heavy metals and polychlorinated biphenyls (PCBs), which are common in electronic waste. The Waste from Electrical and Electronic Equipment (WEEE) directive classifies these as substances of high concern, requiring manufacturers to follow specific safety protocols. However, regulations for LCMs are still lacking, allowing unchecked industrial discharge of these compounds into the environment. This inconsistency highlights the need for international cooperation to develop effective guidelines and best practices for managing LCM containing electronic waste (e-waste).

Innovative approaches to mitigation

As awareness of LCMs' environmental impact grows, researchers are developing advanced methods to detect and reduce their presence. One promising approach involves the development of targeted and non-targeted analytical techniques for detecting and quantifying LCMs in water and sediment samples. These methods, utilising advanced gas and liquid chromatography coupled with high-resolution mass spectrometry, can provide valuable data for assessing contamination levels and trends over time.

Additionally, scientists are exploring innovative treatment options for wastewater containing LCMs, as traditional methods may not effectively remove these compounds. Advanced technologies, such as oxidation processes, are being tested for their potential to break down from water. Ongoing research aims to understand how LCMs behave in water treatment plants and drinking water sources to create effective solutions.

Igniting change: Why public awareness and action are key to safer e-waste disposal

Increasing public awareness about the environmental risks linked to e-waste is essential for promoting responsible consumption and sustainable practices in the industry. Educational campaigns aimed at manufacturers, consumers, and policymakers can encourage greener production and safer disposal methods to reduce the risks posed by LCMs.Community involvement in monitoring local water quality can also be powerful. Citizen science initiatives will allow people to actively participate in tracking water health, creating valuable data on LCM contamination in local ecosystems and helping communities advocate for cleaner water sources.

Charting a sustainable path forward: Collaborative efforts to combat LCM risks

As demand for LCDs rises, so does the need for responsible LCM management. The environmental and health risks associated with LCMs make it crucial to address this issue through collaborative research, advanced treatment solutions, and stronger regulations. By focusing on sustainability and public health, we can meet the challenges posed by LCMs and work toward a safer, cleaner future for our planet. A multidisciplinary approach to understand and address the impact of LCMs is essential to protect ecosystems and human health.

Journal reference

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