GREEN CHEMISTRY

Water treatment chemicals primed for green transition

Growing market familiarity means bio-based and greener chemicals are ready for greater uptake in water treatment. In which applications and industries will they find most favour?

Market Map Published: 21 August 2024 Victor Smith

Decarbonisation, reducing pollution and improving circularity are critical challenges reshaping the chemicals market, fuelling the market for increasingly cost-competitive bio-based and 'green' water treatment chemicals. Utilities and industries are increasingly conscious of the carbon footprint of the products they source, while increasingly strict discharge permits, particularly around phosphorus, mean that unconventional chemistries are becoming more sought after.

'Green' chemistry is an umbrella term encompassing a broad range of bio-based chemicals and other renewable, circular or sustainable chemical technologies and manufacturing processes. Cooling water, wastewater and sludge applications hold the strongest opportunity for green chemistry, with GWI expecting double-digit growth in the green segments of these markets in the next 10 years. The chemicals typically used in these applications (coagulants and flocculants, and scale and corrosion inhibitors) are the most technically suited to bio-based and renewable production methods and currently show the greatest transition to green alternatives. Bio-based feedstocks are likely to supplant a significant portion of conventional inputs, especially fossil fuels. For inorganic and mineral-based chemicals, meanwhile, a key shift will be the transition to using recovered and recycled rather than virgin feedstocks. New products and processes are coming to market directly from the R&D of major manufacturers, as well as through partnerships between established and emerging firms.

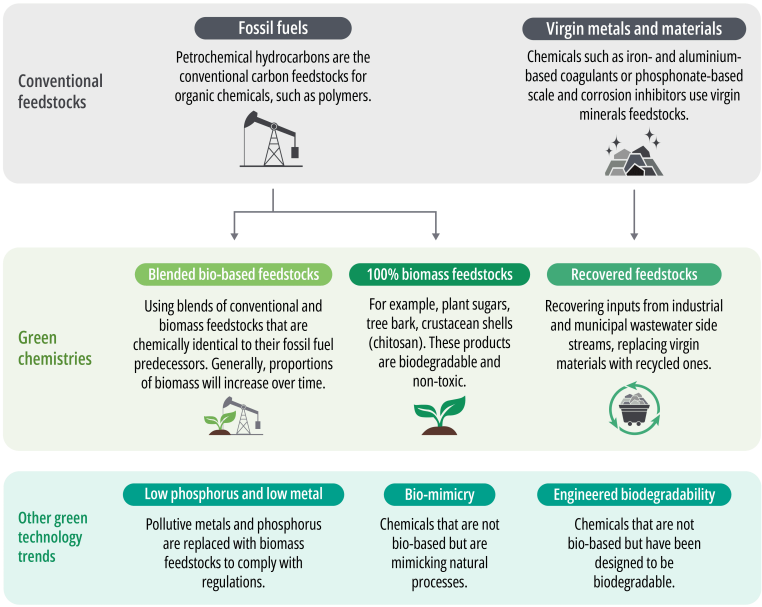
Europe currently leads in the market penetration of bio-based and green water treatment chemicals, which is estimated at around 2-3% currently. The North American market is slightly less mature, at an estimated 1-2% penetration. While the regulatory impetus is weaker than in Europe, the US market is expected to shift quickly as government and investor attention catch on. Company-level environmental targets and mandates will become increasingly influential as investor and public pressure grows.

Where is the market headed?

While the market increasingly favours sustainable formulations, this transition is unlikely to unfold as a linear progression from conventional to bio-based chemicals. The gradual substitution of petrochemical with biomass feedstocks will work in tandem with emerging circular processes that capture and reuse essential inputs like phosphorus and minerals. Indeed, much of the market prefers the terms renewable and sustainable chemistry, rather than purely bio-based, reflecting the various strategies and technologies at play.

PATHWAYS AWAY FROM TRADITIONAL FEEDSTOCKS

Chemicals are shifting away from traditional feedstocks with green chemistry. Bio-based feedstocks offer a alternative carbon source to fossil fuels, whereas virgin minerals can be displaced by renewable sources.



Source: GWI

Currently, few 100% bio-based products are used commercially; instead, biomass feedstocks are predominantly mixed with petrochemical inputs to make *greener* blends, with the ratio of biomass to fossil-fuel increasing over time. Darin Wrazidlo, product line manager at Kurita America, explained that the first step is to replace traditional formulations with *greener* chemicals to help customers navigate the transition to 100% bio-based products: “As more customers adopt these products, it will eventually become the norm.”

Rather than legislations mandating the use of green chemistry, regulations to mitigate pollution, coupled with the growing prioritisation of emissions reductions and sustainability targets, are driving the adoption of renewable alternatives. “There are not regulations around bio-based chemicals, there’s no government forcing anyone to use them,” pointed out Jeroen Koppes, global marketing director at Solenis. “But for the industry to become carbon neutral by 2050, we need to move to bio-based chemistries.”

As industrial end-users commit to initiatives such as the Science-Based Targets, bio-based alternatives will be increasingly preferred, especially in the drive to reduce scope 3 emissions. “We already have some key global customers who are asking us for the carbon footprint of our products, and that is starting to drive product-use decisions,” said Wrazidlo. Changing attitudes are key in driving the adoption of green alternatives. “There is this mindset of wanting to gradually move away from fossil fuels, and that's now possible,” explained Sampo Lahtinen, senior VP of the Kemira Growth Accelerator. “It's moving from being able to do it to actually doing it. This is kind of a transitional moment, what we are seeing.”

While many green chemistries are likely to remain at a premium (which varies substantially, from 10 to 100% greater) to conventional products, prices are coming down and the associated lifecycle cost savings are increasingly recognised. "The main challenge is to support and help customers not just to compare the cost of chemicals products in price by tons, but to make a global economic assessment of the operation of a WWTP, including chemicals, sludge discharge and maintenance costs," explained Veolia's Hydrex global marketing manager, Sylvaine Leriquier. Additionally, carbon pricing systems such as the EU Carbon Border Adjustment Mechanism will reduce the relative cost of bio-based options. This scheme, set to be fully implemented in 2026, will impose carbon taxes on goods imported into the EU, thereby improving the cost competitiveness of green chemicals.

WHO'S GOT THE RIGHT FORMULA FOR GREEN GROWTH?

The largest chemicals companies are committing significant proportions of their R&D spend to developing bio-based products and greener processes. Partnerships are key to commercialising new products and bringing down costs, with smaller firms leveraging the scaling-up power of established manufacturers to take their products to market.

Company	Geographies*	Green chemistry market strength	Key applications for green chemistry	Description
Kemira	Europe and North America	Leader		Offers bio-based sludge dewatering polymers and renewable inorganic coagulants.
Kurita	Asia Pacific, Americas	Leader		Bio-based chemistries for wastewater, with future activity in sludge and cooling water.
Italmatch	Global	Leader		An early innovator for bio-based chemistry and investing in phosphorus recovery.
Veolia	Global/Europe	Leader		Active in food and beverage and hydrocarbon processing with its plant –based-coagulant.
SNF	Europe	Leader		Offers bio-based flocculants using the biomass-balancing concept.
ChemTreat	-	Medium		Longstanding FlexPro line of phosphorus and zinc-free cooling products.
Dober	North America	Medium		Fully bio-based coagulants and flocculants, for municipal and industrial applications.
Nalco/EcoLab	Global	Medium		Focuses on zinc and phosphorus free chemistry, but some enzyme-based chemicals.
Solenis	North America	Medium		Bio-based chemicals in development pipeline.
Solugen	North America	Medium		Bio-based products for use alongside conventional ones to improve efficiency.
Nouryon	Global	Medium		"Eco-premium" solutions, including bio-based polymers, contributed 32% of 2023 revenue.
Ion Exchange	Global	Medium		Offers a variety of green chemicals for industrial applications.
SERVYECO	Europe	Small		Spanish market player offering bio-based coagulant BEWAT.
Lygos	North America, Middle East, Europe	Small		Biodegradable anti-scalants offered, with bio-based versions to be released soon.
Sudoc	Europe	Small		Its TAML chemistry mimics enzymes to create catalysts for oxidation processes.
Mvest Water	Europe	Small		Provides bio-based chemicals for ZLD applications in various industries.
Acorn Water	UK	Small		Active with its bio-inspired flocculant. NanoCarbon for micropollutants launched soon.

Applications: Municipal wastewater treatment; Industrial wastewater treatment; Cooling water; Sludge; Desalination

Geographies specifically for bio-based or green chemistry.

Source: GWI

Industry warms to green cooling treatments

The demand for cooling water across a variety of industries has created a sizeable market for green chemistries. Scale and corrosion inhibitors currently account for 70% of the global chemical spend in cooling applications according to GWI WaterData.

Phosphorus is a universal concern for cooling water applications, with increasingly strict discharge limits driving the market for greener chemistry. As scale and corrosion inhibitors transition from conventional feedstocks to renewable and environmentally friendly alternatives, phosphates and heavy metals are being phased out. Manufacturers are reducing concentrations incrementally with each new iteration. Kurita's current products contain 80% less phosphorus and heavy metals than conventional formulations, for example.

The strategy of reducing phosphate and heavy metal concentrations before transitioning to bio-based feedstocks is more prominent in the American market. In Europe meanwhile, significant investment is going into phosphorus recovery and reuse. The EU-backed FlashPhos project is developing a thermochemical process to recover phosphorus from industrial and municipal wastewater sludge. Italmatch, a partner in this project, anticipates a large market for phosphorus recovery once upcoming changes to the EU UWWTD are in place. "The legislation will force the water treatment plants to either store the phosphorus containing sludge or deliver it to companies that will recover the phosphorus content and bring it back to the market in whatever form," explained Filip Dutoy, global business development and marketing manager at Italmatch. The company plans to use recovered phosphates in its low phosphorus scale and corrosion inhibitors, demonstrating a circular yet pragmatic approach to improving the sustainability and maintaining the performance of its products. "Very often, by replacing phosphorus with something else you introduce other things which are potentially even worse for the environment," noted Dutoy.

While azoles are a less prominent regulatory focus than phosphorus, they are a source of growing concern. They are highly toxic and non-biodegradable but are increasingly being replaced by bio-based alternatives to produce non-toxic corrosion inhibitors. “We are reaching an azole-free copper protection program, and it will be a game changer, especially since the market has been looking for these environmentally friendly products for some time,” noted Wrazidlo. Solugen, a US based scale-up, has also recognised the potential of this market. “[For end-users], azoles are a concern in terms of their cost. Our products allow end-users to partially replace azoles to bring the overall formulation cost down while improving performance,” said chief commercial officer Tom Richardson.

While the market penetration of bio-based chemicals has been greater in wastewater treatment than in cooling applications, adoption across all sectors is rising. “Historically, green solutions in the water treatment industry have been perceived as costly and often associated with performance trade-offs,” said Tee Mariga, director of water treatment at Lygos. The California-based scale-up has advanced beyond conventional polyaspartate offerings to provide solutions with functional derivatives tailored to specific applications, with scale and corrosion inhibitors being a core market. "We have strategically positioned our solutions to facilitate a transition to bio-based alternatives," explained Mariga. "For example, our petro-based polyaspetate is available in the market to give a proof of concept and a preview of what the bio-based is, with no compromise in performance."

Pioneering a new ‘chemienzymatic’ technology platform for chemical manufacturing, Solugen is making waves in the cooling water space. “We use highly efficient engineered enzymes to start the chemical reaction and metal catalysis to optimise throughput. By marrying the best of both biology and chemistry together, we have developed a process that allows us to maximize yield while offering a significant reduction in carbon footprint,” explained Richardson. Its bio-based AcquaCore series is designed to increase the efficiency and reduce the dosing concentrations of phosphorus and azoles. Solugen is currently working on the next generation of products that hope to further reduce or eliminate the need for some of these more toxic chemicals.

The widespread uptake of bio-based alternatives will be dependent on their price. The new technology platforms of Solugen and Lygos are enabling significant cost reductions, changing perceptions around the perceived trade-off between price and efficacy. Lygos expects to market its upcoming bio-based product at a lower cost than its existing petrochemical formulation, and Solugen’s products are claimed to be cost-competitive with incumbent solutions. Partnerships between scale-ups and established firms will be the key mechanism for delivering these products at scale. Last month Solugen and Kurita partnered to develop a range of bio-based scale and corrosion inhibitors under the Kurita TowerNG brand, targeting the cooling water market. Set to open in 2026, Solugen's new facility in Minnesota will manufacture these products.

Bio-based and renewable coagulants taking a hold in wastewater treatment

Industrial applications have been the immediate opportunity for bio-based coagulants. As these chemicals perform well for solids, fats and oil separation, opportunities have been seized in food & beverage, oil & gas and mining markets. For Kurita, the North American food & beverage market vertical is a key focus for its chitosan-based coagulant, due not only to synergies with food safety certifications, but substantial cost reductions (due to lower chemical dosing) and carbon savings. Wrazidlo explained: “A protein harvest plant requires 500 parts per million of ferric sulphate or ferric chloride coagulant to treat their wastewater. Depending on the flow rate, the cost could be upwards of $50,000 per year. Using a shellfish-based product can reduce the feed rate and the cost by 80% annually and is better for the environment.”

Veolia has its sights particularly on both the food and beverage and hydrocarbon markets with its long-standing plant-based coagulants, part of the Hydrex range. Veolia told GWI that the plant-based coagulants’ share is growing year after year, with demand driven by the need for water reuse and the economic viability, operational efficiency and environmental benefits of these products. Solugen’s Versa360 product works in tandem with conventional coagulants and flocculants, and is targeting oil and gas markets to reuse more produced water, avoiding challenges and costs regarding produced water disposal.

WHICH APPLICATIONS ARE GOING GREEN?

Bio-based and green water treatment chemicals are exhibiting strong growth in most applications. Growth rates are starting from a rather low base of market penetration. Additionally, CAGRs for the green segment of the European and North American markets are likely higher, due to increased concern with sustainability in these regions. Consumer facing industries such as data centres and personal care products are likely to see an increased adoption of green alternatives.

Key applications	Predominant theme	Relative uptake in the market	Global 5-year CAGR
Sludge management Dewatering polymers are a key opportunity as they are heavily reliant on fossil fuel feedstocks. Bio-based chemicals are blends, likely to shift to increasing proportions of biomass overtime.	Blends	↑ High	8–10%
Industrial wastewater Bio-based coagulants are most established here with strengths in oil separation. Food and beverage wastewater, oil and gas and mining are key industrial opportunities.	Bio-based	↑ High	8–10%
Cooling water Reducing and then eliminating phosphorus, azole and heavy metal concentrations is driving the market. Phosphorus recovery is also gaining interest. 100% bio-based formulations are set to be marketed soon.	Blends, bio-based and p-recovery	–/↑ Medium-high	7–9%
Desalination Strong drive from Middle East desal plants for bio-based scale and corrosion inhibitors for environmental stewardship.	Bio-based	–/↑ Medium-high	10–12%
Municipal wastewater Inorganic coagulants will shift towards renewable rather than virgin feedstocks and applying organic coagulants to phosphorous reduction is being investigated.	Renewable feedstocks	— Medium	5–7%
Drinking water Not an immediate priority and it is technically challenging to produce a bio-based formulation that meets drinking water standards. However, there are some cases of starch-based chemicals being used in Europe.	–	↓ Low	–
Boiler water Challenging due to the high temperature and pressure.	–	↓ Low	3–4%

Source: GWI

To date, there has been limited activity in the municipal space for bio-based coagulants. Kurita previously attempted to enter the US municipal chemical market but according to Wrazidlo the firm found that "municipalities have full-time staff and use commodity chemicals as well as have specific treatment requirements."

However, investigations have been ongoing in the UK regarding applying bio-based (or natural) coagulants for phosphorus removal. The recently completed £3.15 million OFWAT funded project Alt-P project, led by United Utilities explored metal-free alternatives for phosphorus removal for rural treatment works, including natural coagulants. Callum Grundy, senior process engineer at United Utilities explained: "The UK water sector is seeing more permits applied to small rural treatment works than ever before. Quite often, the bigger challenge when dosing ferric sulphate or aluminium-based products is not necessarily hitting the phosphorus target but managing the metal carryover because water companies are also permitted on the residual metal concentration."

Initial testing showed limited phosphorus removal when the natural coagulants were used alone but when combined with ferric sulphate, the ferric dosing could be cut by 50%, without comprising phosphorus reduction and significantly reducing the iron residual. As the costs involved are significantly higher, uptake is likely to be targeted at rural sites and new build small-medium sized treatment works. Grundy told GWI: "Natural coagulants have a more expensive unit cost than metal-based coagulants which means they are likely to be targeted only where they are needed. On new-build capital projects, it could be possible to save millions (GBP) if you can design out mechanical equipment, then this approach would pay for itself."

While organic coagulants are likely to see increased market activity in the wastewater space, a full displacement of inorganic coagulants is unlikely, particularly for phosphorus removal. Jean-Christophe Ades, senior marketing manager for Kemira's Industry & Water Segment stated: "Organic coagulants as they look today cannot replace inorganic coagulants. They can be a support in the process, but to meet the stringent requirement of phosphorus levels you need an inorganic, metal containing product." Pressures to reduce iron concentrations are less of a concern in Europe. "The Urban Wastewater Treatment Directive is absolutely not talking about iron, which is a very common and inert metal," stated Ades.

Kemira is improving the sustainability credentials of its inorganic coagulants by transitioning from virgin to recycled feedstocks. Already, 70% of its inorganic coagulant feedstocks are recycled, sourced from steel, titanium dioxide and other industries co-products. "Because you don't have any carbon in [inorganic coagulants], the focus is more on circularity," explained Ades.

Weaning dewatering away from petroleum

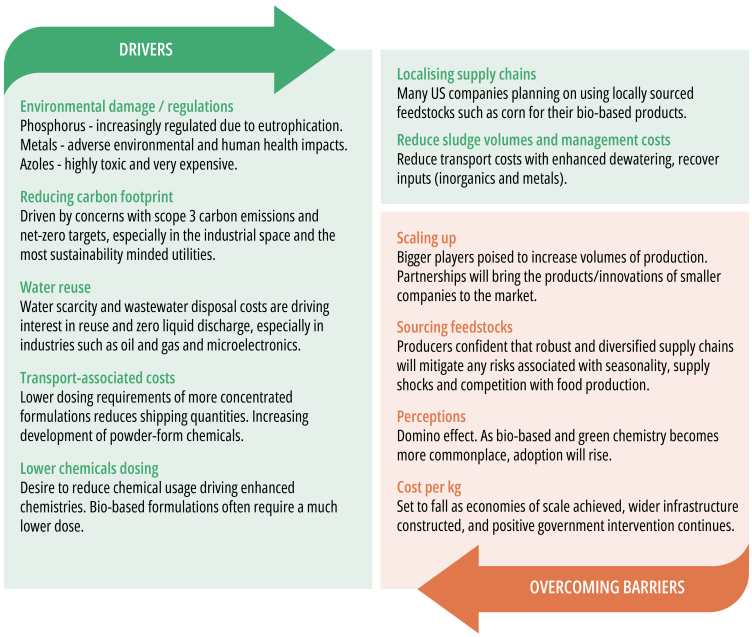
Sludge dewatering polymers are heavily dependent on fossil fuel feedstocks, with petroleum polyacrylamide taking most of the market share. By transitioning to blends of conventional fossil fuels and renewable feedstocks using the mass-balance concept, equally high-performing products are produced. The polyacrylamide molecules are identical in both versions, both chemically and in terms of performance.

This application has been the immediate opportunity for Kemira, its SuperFloc BioMB flocculant has been on the market since 2022, but the firm is seeing a recent shift in the market. “Even in the last 12 months we have seen good progress here going from awareness to growth, it’s not like there is sudden change but this a pivotal moment,” explained Lahtinen. The firm has a target for 500 million euros of its revenue in 2030 to come from renewable carbon feedstocks – primarily from its sludge polymer.

Growing utility focus on decarbonisation, improved product availability and awareness are key factors in this shift, with some utilities beginning to request bio-based chemistries in their tenders. “If our water treatment customers look at their footprint, of course, they first look at the energy but if they have already switched to renewable energy. Then what? Then the next step to reduce their carbon footprint is usually chemicals," explained Lahtinen. While the bio-based coagulant is likely to remain at a premium price, he emphasised that in the past two years prices have become more “palatable” but “there will be a premium as it is a premium product.”

SUSTAINABILITY AT THE FOREFRONT

A multitude of drivers are pushing the water treatment chemicals market towards bio-based and other strands of green chemistry. While these formulations may come at a premium, lifecycle cost savings can make an attractive business case with savings from water reuse, sludge management and reduced chemical dosing.



Source: GWI

Kurita is looking to enter the North America sludge dewatering market, to apply its blended (shellfish and metal salt) coagulant to the food and beverage industry. “Despite technically being a coagulant, our shellfish-based product acts like a polymer, producing a tighter, smaller floc with less moisture. From a dewatering standpoint, it has much better performance and cleaner water coming out of the process, which you can potentially reuse,” explained Wrazidlo. Kurita has 100% bio-based product currently being evaluated with lab trials, and field trials expected in Spring 2025. Whereas Kemira is less focused on the 100% bio-based goal but gradual transitions to provide the best gains. “We are not saying that we will stop using fossils; that's not realistic. Fossils will still be around, but we want to gradually lessen our dependency on them and help our customers do the same,” explained Kemira’s Lahtinen.

Further opportunities for bio-based polymers may evolve from the circular economy, with the UK utility sector exploring producing sludge dewatering polymers from its own operations. A recently launched £6 million OFWAT-funded project, Biopolymers in the Circular Economy, will extract biopolymers using a pilot Kaumera Nereda Gum plant set for operation in April 2025 at a United Utilities site. Waste reduction and circularity are the major drivers of the project. Investigations regarding end-markets will continue until September 2027, including agricultural and plastic end-markets, alongside the feasibility of internal

dewatering polymer markets for wastewater utilities. If the recovered polymers can be used for sludge dewatering it would reduce plant scope 3 carbon emissions.

“It’s a real kind of voyage of discovery at the moment, we need to understand, how much [dewatering polymer] we can produce because if we're only going to be producing a small amount, then it might not be useful to be used within the water sector,” explained Geraldine Shortland, senior process engineer at United Utilities.

Nature inspired chemistry for micropollutants

Micropollutants have been rapidly moving up the agenda especially in Europe and North America. While PFAS takes most of the spotlight, especially in North America, it is not the only micropollutant seeing intensifying regulatory control. Pharmaceutical residues are key features in recent legislation in the EU and UK, with both Sudoc and Acorn Water setting sights on this market. Sudoc offers sustainable chemical products using its proprietary TAML chemistry, which mimics natural enzymatic processes in the human liver. Acorn uses non-hazardous carbon nanoparticles combined with cationisation, bio-activators and essential bulk elements. Opportunities are hot in the EU with the Urban Wastewater Treatment Directive requiring an 80% reduction in micropollutants in plants serving over 150,000 p.e. (deadlines are incremental: 20% of plants by 2033, 60% by the end of 2039, and 100% by 2045), and some in the market expect similar measures to be adopted by the UK.

Acorn Water is preparing to launch its proprietary product, NanoCarbon, a non-hazardous adsorptive coagulant specifically designed for micropollutant removal, targeting the UK utility market. As water utilities face tight budgets and increasingly stringent regulations, NanoCarbon’s ability to enhance micropollutant removal in existing treatment tanks, without the need for costly quaternary treatment installations, could be highly appealing. Holland stated: “NanoCarbon can eliminate the need for these quaternary capital investments by achieving up to 99% micropollutant removal in existing tertiary treatment tanks, potentially saving UK utilities millions in investment costs.”

US-based Sudoc is setting its sights on the European micropollutant removal market, recently opening its first European office in Amsterdam. First, the firm will target industrial wastewater treatment before scaling up to municipal wastewater treatment. Its bio-mimetic catalyst works in tandem with advanced oxidation treatment technologies improving their efficiency and costs. CEO Roger Berry stated: “Sudoc’s patented chemistry is relevant to any process using oxidation including electrochemical oxidation systems where we have found a 40-fold reduction in energy in treating important micropollutants. This is a game changer.”

*Further research on dedicated forecasts for the bio-based and green segments of the water treatment chemicals market can be found on **WaterData** in the coming weeks.*

Terminology

Azoles: Five ringed compounds with nitrogen atom at centre, used in corrosion inhibitors. Highly efficient but toxic.

Bio-based chemicals: Using biomass as the carbon feedstocks to replace or reduce reliance on conventional fossil-fuel carbon sources. This definition includes blends of fossil fuels and biomass, and chemicals that are 100% biomass.

Biomass: Natural organic material from plants and animals.

Coagulant: A chemical added to initially destabilise, aggregate, and bind together colloids and emulsions to improve settleability, filterability, or drainability.

Corrosion inhibitor: An additive that prevents the corrosion of metal pipes, towers and other systems. Often combined with scale inhibitors in a single product.

Flocculant: An organic polyelectrolyte, used alone or with metal salts (typically after a coagulant), to enhance floc formation and increase the strength of the floc structure, promoting solid-liquid separation.

Inorganic: Mineral-based chemicals including virgin and renewable mineral feedstocks, for example metal-based coagulants.

Organic: Chemicals based on carbon. Ideal for replacing conventional fossil fuel carbon with bio-based carbon feedstocks.

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