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Photocatalytic Degradation of Microplastics in Aquatic Environments Using Solar-Activated Bismuth Oxychloride

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Abstract--- Microplastic particles have now been reported in freshwater and marine systems and their ability to withstand traditional water treatment has put their destruction, not their removal to the top of the engineering agenda. Bismuth oxychloride has been of particular interest in this context, due to its structure containing a series of layers of $[Bi_2O_2]^{2+}$ which generates an internal electric field that separates the carriers generated by the photons, but also due to its surface chemistry which favours the formation of the hydroxyl radicals which are the most commonly implicated in polymer chain scission. Its large band gap, however, (3.19 – 3.60 eV) restricts the light absorption to almost exclusively the ultraviolet part of the sun's spectrum, which accounts for only 3-5% of the solar spectrum, and thus is not a property of the pure material but rather a materials design challenge. This paper discusses the structure and electronic mechanism of BiOCl photocatalysis of microplastics in water and reviews the strategies such as facet control, vacancy engineering, heterojunction construction and surface hydroxylation to broaden its response to visible light and enhance charge utilization. The degradation performance of polyethylene, polyethylene terephthalate, polystyrene and polypropylene targets is reported and the analytical data to support the presence of true chain scission and mineralisation as opposed to simple fragmentation is evaluated. Operating parameters that influence the activity such as pH, temperature, particle size, catalyst ratio to polymer and light source are discussed, along with reactor configurations that can utilize natural sunlight. The paper concludes that solar-activated BiOCl is a viable pre-treatment or polishing method for microplastic-containing waters, but quantitative mineralisation data and standardised metrics and outdoor testing are still the main challenges to scale-up.

Keywords--- Bismuth Oxychloride, Microplastics, Photocatalysis, Reactive Oxygen Species, Solar Light, Advanced Oxidation Processes.

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I. Introduction

Microplastic contamination is no longer a rare coastal monitoring phenomenon, but a recognised feature of almost all the aquatic compartments studied. The results from a synthesis of 168 studies reporting particle concentrations in marine and estuarine systems showed that particle concentrations were greater than the limit of detection from around 0.001 to 1.5×10^5 MPs/m^3, and greater than the limit of detection from 0.0001 to 2.08×10^6 MPs/m^3 in 75 freshwater studies (Cross et al., 2025). These wide range values are not only related to environmental variation but also to methodological differences, but the results are clear: Microplastics are found in the water column in concentrations that make them an uninterrupted, low dose exposure pathway for aquatic organisms. The problem is narrow chemically in an analytically convenient manner. About 90% of the plastics recovered across the environments studied are low-density polyethylene, high-density polyethylene, polypropylene, polyvinyl chloride, polystyrene, or polyethylene terephthalate (Bellasi et al., 2020). The overwhelming majority of the target material, however, is comprised of five commodity polymers, all of which are polyolefins or saturated polyesters containing no hydrolytically labile bonds that can be broken by the environment within a short period of time. Conventional treatment trains were not specifically engineered to treat such particles. The coagulation/flocculation/sedimentation and sand filters are very effective at removing

larger microplastics, and their effectiveness decreases significantly with smaller microplastics, while membrane processes transform a water-phase issue into a sludge-phase issue. The other logic, which is advanced oxidation, would be to break down the polymer instead of moving it. One of these classes is heterogeneous photocatalysis where a semiconductor absorbs photons with energy greater than its band gap, creating electron–hole pairs, and then transforming water and oxygen molecules already on the semiconductor surface to create reactive oxygen species that attack the polymer surface. The technique is naturally suited to the suspended particles that have a large accessible surface area per mass, as the attack is initiated at the solid–liquid interface. BiOCl is an appealing member of this family of materials for three reasons. First, the internal electric field created between $[Bi_2O_2]^{2+}$ layers, which favors separation of the photo-induced carriers, is generated; second, bismuth oxyhalides have anisotropic layered structures where $[Bi_2O_2]^{2+}$ layers are intercalated by halide ions (Li et al., 2024). Secondly, it is non-toxic and inexpensive (Xu et al., 2016). Third, and most significantly for microplastic applications, it could be easily processed to contain a large number of hydroxyl groups, which have been demonstrated to be very important for the degradation of polymers as they increase the production of hydroxyl radicals (Xiao et al., 2024). The obstacle is not electrical, it's optical. The BiOCl has a very broad band gap of 3.19-3.60 eV, which means that it can only absorb ultraviolet radiation, representing only about 3-5% of solar energy (Xu et al., 2016). Without modification, it is not solar activated in any meaningful engineering sense to be able to use 3-5% of the incident solar spectrum. The research question is thus clearly formulated: What is required to make the sunlight effective as a driver of BiOCl and what can be reasonably expected in terms of performance when this is accomplished?

The paper is organised as follows: In section 2, microplastics are defined as a target substrate and distinct degradation rates for microplastics are explained. The structural and electronic mechanism of BiOCl photocatalysis is summarized in Section 3. In section 4, the four main pathways to solar activation are considered. Section 5 looks at the reported degradation performance for different types of polymers, Section 6 analyzes the mechanistic evidence for chain scission and Section 7 addresses operating parameters. Section 8 discusses reactor engineering and Section 9 highlights the outstanding challenges.

II. Microplastics as a Recalcitrant Substrate

There are three properties of microplastics which differ from the dissolved organic pollutants that photocatalysis was designed to remove. The first is the compositional heterogeneity. PE and PP are only C–C and C–H bonds, PET has ester bonds, and PS has a phenyl group on every second backbone carbon. These differences alter the intrinsic photoreactivity, as well as surface chemistry available for the ROS attack. Therefore any statement regarding "microplastic degradation" needs to be qualified with regard to the type of polymer and comparative studies indicating one efficiency figure for a mixture must be interpreted with caution. The second is that microplastics are not passive vehicles for co-contaminants, but rather are themselves co-contaminants. Particles have a high surface area to volume ratio and are hydrophobic, absorbing metals and organic micropollutants which can be released when the polymer matrix is oxidised. Any treatment that just breaks up particles can turn an easier-to-remove solid into a more mobile and more bioavailable dispersion of oxidised oligomers and contaminants that are attached. The endpoint should be complete mineralisation or at least the loss of mass and conversion to CO_2 should be demonstrated. The third is analytical. When a pollutant is dissolved it is removed from the aqueous phase, and disappearance is measured. One part of a microplastic particle can lose, for example, a third of its mass, but retain exactly the same number of particles in the sample, or shrink the diameter of the particle, but without any change of composition, or oxidise to carbon dioxide and short chain acids. Degradation must therefore be triangulated from a number of independent lines of evidence, as developed in Section 6.

III. Bismuth Oxychloride: Structure, Electronics and Photocatalytic Basis

BiOCl crystallises with the matlockite structure, a tetragonal structure of $[Bi_2O_20]^{2+}$ slabs alternating with double layers of chloride ions along the c-axis. This alternating process is the source of the most useful property of this material. The oxygen and chlorine layers have different electronegativities, which polarises the lattice with a permanent internal electric field perpendicular to the slabs. This field separates electron–hole pairs away from each other, thereby minimizing the bulk recombination rate of electrons and holes that causes numerous wide-band-gap oxides to be much less efficient. Microplastic work is important since the rate limiting step in polymer photocatalysis typically is not the photon absorption but the lifetime of the carriers until they reach the solid–liquid interface. This has enabled BiOCl to be used to efficiently deliver carriers to that interface over

nanometre-scale distances, partly overcoming the challenge of its low visible-light absorption. There is a strong coupling between crystal facets at an interface that leads to the importance of facet control in this material: the degree of lattice mismatch is determined by the type of crystal facets at the interface and hence by the efficiency of charge injection (Sun et al., 2015). The photocatalytic cycle is itself the typical semiconductor one. If the energy of the photon is higher than the band gap, the valence band electrons are excited into the conduction band and holes are left behind. The conduction-band electrons convert O_2 to superoxide ($O_2\bullet^-$) and the valence-band holes oxidise adsorbed water or surface hydroxyl groups to hydroxyl radicals (•OH). The polymer is attacked by both species as well as by hydroperoxyl radicals, which are formed in the protonation of superoxide. The surface hydroxyl population is more important than the bulk bands for micro-plastics. A comparative study of hydroxyl rich ultrathin BiOCl and conventional BiOCl nanosheets was performed, and the mass loss of the BiOCl-X was 24 times that of the nanosheets when the same microplastic was targeted (Xiao et al., 2024). The enhancement was identified to be due to surface hydroxyl groups by electron paramagnetic resonance and radical trapping experiments, which significantly increase the amount of hydroxyl radicals produced and are important for microplastic degradation (Xiao et al., 2024). It is assumed that surface functionalisation cannot simply be the 'second-best' optimisation; in fact, this would be the main lever.

IV. Routes to Solar Activation of BiOCl

The literature contains only four strategies, and they are not mutually exclusive.

4.1 Morphology and Facet Control

Carriers are separated by the crystal habit since the internal field is anisotropic. Nearly all of the {001} facets were exposed in the preparation of nanosheets with almost fully exposed active {001} facets, and the defect population, which is largely the vacant Bi (vac) for thicker nanosheets, becomes the triple vacancy associate as the thickness decreases to atomic scale, as shown by positron annihilation spectroscopy (Guan et al., 2013). The solar photocatalytic activity was greatly enhanced by the enhanced adsorption, more efficient separation of the electron–hole pairs and more reductive photoexcited electrons even at extremely low loading of the catalyst (Guan et al., 2013). The last is important for microplastic applications: the ratio of mass of catalyst to polymer is a cost driver, and the fact that activity is observed at low loading is a real advantage. The morphology also seems to have an impact on the performance of the polymers. The efficiency of the degradation was 8.8 and 6.9 times higher for spherical and nanosheet BiOCl preparations, respectively, when applied to polyethylene terephthalate microplastics after they were pre-treated with hydrothermal treatment under the same conditions (Lin et al., 2024). The difference between the two morphologies is smaller than the pre-treatment effect, but is still there, thus indicating that habit is a controllable variable.

4.2 Defect Engineering

The presence of oxygen vacancies has been shown to be a well-known method for modifying the electronic structure of BiOCl and thereby improve the photooxidation activity (Cui et al., 2018). This approach is known to have a potential drawback, however: the bulk defects created by the dopants can serve as recombination centres to reduce photoactivity, while surface defects can act as charge traps, thereby reducing recombination. Limiting the defects to the surface thus preserves the benefit without incurring the penalty: the ultrathin nanosheet morphology does exactly this. In the more aggressive variant, dual anion vacancies are introduced. With the help of polyphenol rich extracts from green tea and spinach, the researchers synthesized the dual vacancies of oxygen and chlorine in BiOCl at ambient conditions which consequently increased the photocatalytic activity of the material (Li et al., 2018). The removal of chlorine changes not only the absorption edge, but the internal field itself, since chlorine is located in the interlayer galleries which set the lattice polarisation. Whether this change will lead to better interaction with a hydrophobic polymer surface remains to be seen, and would be a direct test.

4.3 Heterojunction Construction

Heterojunctions overcome the two problems mentioned above in a single shot. The combination of BiOCl with a semiconductor with an appropriate band alignment provides the material with absorption it lacked, and also provides a spatial separation mechanism that was not required because absorption happened only in the UV. The interface determines the results. A higher lattice mismatching and visible-light photocatalytic activity were found for the BiOI(001)/BiOCl (010) junction geometry, as compared to the other one, with the former being attributed to the short length of the electron diffusion path in the BiOI layer facilitated by the internal fields of the BiOCl slabs (Sun et al., 2015). The lesson generalises: it is not the material combination which

influences the junction performance, but facet combination. Aquatic pollutant degradation biOCl-based heterojunctions reported include deposition of metal on BiOCl, where electrons generated by the photodesorption are transferred to the oxygen vacancy states, and p–n junctions with narrow-gap oxides like $BiVO_4$ and ZnO where the band alignment forces spatial separation of the carriers. S-scheme architectures, where a built-in electric field creates a directionality in the charge transfer process without losing the most redox-active carriers, is another step in the same direction. What these systems have in common is the fact that these systems make the material's main weak point (its poor visible absorption) into a design challenge.

4.4 Surface Hydroxylation and Polymer Composites

The fourth path is not an electrical one, but a chemical path. Incorporating a large amount of the OH group on the surface of the ultrathin BiOCl material has been found to be an efficient strategy for enhancing ROS production and thereby degrade the MPs (Li et al., 2024). This is a surface acid–base strategy, hydroxylated surfaces are more hydrophilic and better wets a hydrophobic polymer particle, and are also more efficient to produce •OH from valence-band holes. One similar method involves incorporation of the catalyst into the polymer. Polystyrene matrix films loaded with BiOCl nanoflowers and nanodisks were observed to undergo an enormous drop in tensile strength after photocatalytic degradation under visible light for more than 90 h, suggesting that the change is more pronounced in the nanodisk-containing film (Li et al., 2024). This is not a water-treatment configuration, but rather an illustration of the activity of BiOCl in intimate contact with a polymer phase (the geometry in which a suspended particle adsorbs onto a microplastic surface).

V. Reported Degradation Performance

Table 1 summarizes data from studies measuring the degradation of microplastics, not just change in colour or turbidity. The comparison is done in a conservative manner, and the figures are given as published, but the following must be noted: Mass loss is not equivalent to area reduction, and area reduction is not equivalent to carbonyl index.

Table 1: Reported Photocatalytic Degradation of Microplastic Targets. Values as Published; Conditions Vary and Figures are not Directly Comparable

Photocatalyst	Target polymer	Key conditions	Reported outcome
BiOCl-X (hydroxyl-rich ultrathin)	HDPE microspheres, 200–250 μm	Aqueous slurry	Mass loss 24× that of BiOCl nanosheets (Xiao et al., 2024)
BOC-S (spherical BiOCl)	PET microplastics, hydrothermally pre-treated	Same conditions as un-pretreated control	Degradation efficiency 8.8× the un-pretreated MPs (Lin et al., 2024)
BOC-N (nanosheet BiOCl)	PET microplastics, hydrothermally pre-treated	Same conditions as un-pretreated control	Degradation efficiency 6.9× the un-pretreated MPs (Lin et al., 2024)
BiOCl nanoflowers / nanodisks in PS films	Polystyrene	Visible light, 90 h	Large decline in tensile strength (Li et al., 2024)
$BiPO_4$	Polypropylene	UV-B, ultrapure water, lab scale	Up to 10.81% reduction in MP area (Egea-Corbacho et al., 2025)
Bi_2O_3/TiO_2	Polypropylene	UV-A, ultrapure water, lab scale	Up to 9.15% reduction in MP area (Egea-Corbacho et al., 2025)
TiO_2 P25 (benchmark)	PE microspheres, 234 ± 12 μm	UV, 8 h, TiO_2:MP ratio 1:1	34.0 ± 1.4% mass loss; 58.5% increase in carbonyl index; mean diameter reduced to 185 ± 13 μm (Aragón et al., 2025)

Two patterns emerge. The first is that the greatest reported improvements are not necessarily the greatest absolute improvements. The 24-fold and 8.8-fold enhancements in BiOCl-X and BOC-S compared to BiOCl nanosheets, respectively, are not against an inactive control, but against un-pretreated polymer. The 6.9-fold enhancement in BOC-N compared to BiOCl nanosheets is not against an inactive control, but against polymer that was not pretreated. These are substantial and believable materials-science outcomes, but they really refer to the increase that can be obtained with the modification and not to the absolute rate that can be obtained. The second is the fact that the absolute performance when exposed to ultraviolet light is relatively low. The $BiPO_4$

and the Bi_2O_3/TiO_2 under UV-B and UV-A reduced the area up to 10.81% and 9.15% respectively in the polypropylene system using ultrapure water (Egea-Corbacho et al., 2025). For comparison, at the same ratio of catalyst/polymer (1:1) and after 8 h of UV exposure, TiO_2 P25 resulted in the degradation of 34.0 ± 1.4% of mass loss in the PE microspheres, which corresponds to an increase of the carbonyl index of 58.5% and a decrease in mean particle diameter from 234 ± 12 μm to 185 ± 13 μm (Aragón et al., 2025). After five cycles, repeated cycling resulted in an increase in cumulative mass loss to 54% (Aragón et al., 2025) suggesting that repeated cycles still lead to additional loss of mass, and not the catalyst is the limiting factor. Taking a look at these studies, it's fair to say that at least photocatalysis of the surface of microplastic fragments is effective, whereas their mineralisation is rather slow over the surface of BiOCl and its composites. The surface oxidation can be demonstrated in hours; the conversion of the carbon backbone to CO_2 is measured over tens of hours at best and will decrease as the surface becomes thicker and acts as a barrier to the reaction.

VI. Mechanistic Picture of Polymer Breakdown

ROS attack on a polyolefin is similar to the regular autoxidation chemistry. Initiation occurs at weak links, manufacturing irregularities and forms alkyl radicals; propagation involves the addition of oxygen to give peroxyl and hydroperoxyl species; branching involves the decomposition of hydroperoxides to give more radicals; and termination involves the quenching of radical pairs. For the heterogeneous photocatalytic variant of this scheme, the initiation is performed by the photogenerated •OH and $O_2•^-$ at the solid–liquid interface, in addition to being carried out by heat or direct photolysis. The chemical signature of propagation is well characterised. The products of photo-oxidation are via hydroperoxide intermediates to carbonyl compounds, and a number of low molecular weight alkanes, alkenes, ketones, aldehydes and carboxylic acids have been observed as degradation products from polyethylene, the hydrophilic members of which are readily biodegradable. The Norrish type I and type II cleavages produce carbonyl-, hydroxyl- and ester-functionalised groups, leading to the appearance of new carbonyl, C–O and O–H bands in the infrared spectrum. This final point is significant for the design of the process because the mineralisation does not have to be complete, allowing the photocatalysis to transform a persistent solid into a bioavailable dissolved substrate. This cascade in the aqueous photocatalytic system was directly demonstrated by the TiO_2/PE study mentioned above, in which a decrease of the initial dissolved organic carbon, the detection of short-chain acids in solution and CO_2 in the gas phase together confirmed the degradation of the initial microplastics (Aragón et al., 2025). The presence of acetic and formic acid in the aqueous phase is a very distinctive feature: these are end products of oxidation which cannot be obtained from a simple desorption or fragmentation process (Aragón et al., 2025). As for BiOCl, the nature of the main oxidant has been investigated by radical trapping. In the PET study, the hydroxyl radical generated through photocatalysis was found to be the most important free radical for the degradation performance of pre-treated PET microplastics in the free radical trapping experiments (Lin et al., 2024). This is in accord with the above hydroxyl-rich surface argument proposed for BiOCl-X and is in contrast with systems where systems superoxide dominates. The sequence of the physical attack is not so well worked out. The surface erosion seems to have occurred before bulk erosion: for pre-treated PET, the pores formed on the surface permitted active species to penetrate the bulk and damage the material (Lin et al., 2024) and the increase of hydrophilicity and specific surface area of the particles also promoted contact between the catalyst and the polymer (Lin et al., 2024). It is not yet known if the interior collapses as has been reported for some visible-light heterojunction polymers, but this question can be addressed for BiOCl with respect to the major commodity polymers.

VII. Operating Parameters that Govern Performance

Compared to the other systems, the performance of this system is extremely sensitive to operating conditions and the efficiency can vary considerably between studies, making it difficult to compare efficiencies across studies. The parameters most consistently identified are pH, temperature, particle size, polymer type, catalyst loading and light source. The pH affects the system in two ways. It controls the surface charge of the catalyst (and therefore the electrostatic interaction with the polymer particle) but also the speciation of the radical chemistry. In BiOCl systems, acidic condition promotes the degradation of microplastics, while alkaline conditions and Coulomb repulsion protect against degradation (Xiao et al., 2024). The alkaline inhibition is at least partially electrostatic; at high pH both the catalyst surface and the oxidised polymer are negatively charged and hence the contact between the two is reduced and consequently the entire process is inhibited. The second most important variable is particle size. The smaller microplastics break down faster, due to increased surface area to volume ratio for attack (Xiao et al., 2024). This has an important corollary in practice; photocatalysis is

best at the size fraction most difficult to separate using conventional methods, and that's why it should be used downstream of, not as substitutes for, conventional separation. The rate is greatly modulated by polymer properties. Otherwise, identical conditions produce significantly less photocatalytic degradation for light coloured polymers or stable polymers (Xiao et al., 2024). There are two interpretations to the above observation. The first is optical, meaning that the incident light is scattered and reflected by pale particles that would otherwise be absorbed by the catalyst. The second is chemical, the stabiliser packages that are added in at the time of manufacture are intended to intercept the radical chains and if there is any residual stabiliser on the surface of the particles then it would do just that. Both explanations have not been tested directly for BiOCl, and it is important to distinguish them because the microplastics usually found in the environment are weathered, and free from additives. The amount of catalyst needed has a maximum value at which it is most effective. Below it, photon absorption is limiting, and above it, turbidity reduces the light penetration and causes more collisions between particles than between particles and polymers. The PE study demonstrated that a very high ratio of TiO_2 to microplastics (1:1) was required to achieve major photocatalytic degradation; this is an unusually high amount of catalyst dose as compared to the treatment of dissolved pollutants. A ratio of TiO_2 to mP of 1:1 was required to achieve major photocatalytic degradation in the PE study, which is an unusually high amount of catalyst dose as compared to the treatment of dissolved pollutants, reflecting the amount of surface area that needs to be covered to intercept a suspended particle. Lastly, light source determines the rate and economics. This complicated process of photodegradation can take several days to several weeks depending on these variables, which hinders the widespread use of it (Xiao et al., 2024).

VIII. From Beaker to Sunlight: Reactor and Process Considerations

And that is precisely where the failure occurs for most water treatment schemes that are based on photocatalysis. The same is true for the treatment of microplastics.

In the case of solar applications, compound parabolic collectors are the most common design. In one study, a CPC was found to be able to absorb photons 70% more efficiently compared to a standard tubular reactor. Moreover, a CPC requires 39% less catalyst under optimal conditions (Prieto-Rodriguez et al., 2012). And both figures are not minor improvements since better photon absorption means lower collector surface, which is the main expense of a solar photoreactor.

The challenge posed by microplastics application is one that is unique in contrast with the process of dissolved pollutants. The interaction between the solid suspension and photocatalytic process takes place when there is physical contact between the catalyst and the polymer and this is determined by hydrodynamics. The reactor that has vigorous mixing achieves maximum contact but will require catalyst separation while the immobilized catalyst configuration reduces the surface area and more importantly makes it difficult for a large particle to come into contact with the surface of the catalyst. The proposed process train usually involves placing the photocatalytic reaction after the concentration process such as filtration and flotation to treat a slurry of particles.

There seems to be an emerging trend in coupling of the pre-treatment process with photocatalytic process. The hydrothermal pre-treatment of PET microplastics increased the surface porosity, improved hydrophilicity and specific surface area thus facilitating the contact between the catalyst and polymer Lin et al., (2024) and this resulted in efficiency improvement greater than just using catalyst optimization. In case of solar driven systems where photons are the limiting factor, any pre-treatment process that reduced the irradiation period would be more beneficial than improved catalyst activity.

IX. Challenges and Research Priorities

There are four barriers to be overcome to enable a deployable solar activated BiOCl process. The first one is the mismatch in absorption. In Section 4, modifications are discussed that extend the response of BiOCl into the visible, but the improvement of the reported results is typically demonstrated in dye-degradation benchmarks, not against the targets of microplastics. Visible-light activity data, against polymer particles, is clearly needed as there is a significant difference in the physicochemical requirements between a polymer particle and a dissolved dye (hydrophobic contact, surface wetting, slow interfacial charge transfer to an insulating substrate). The second is quantification. All the factors of mass loss, carbonyl index, particle size distribution, TOC removal and CO_2 evolution measure something different and not all five factors have been reported in studies. The TiO_2/PE work, which was gravimetric, carbonyl index, particle sizing, dissolved organic carbon, short-chain acid

identification and gas-phase CO_2, is an excellent example of a full data set. Establishment of at least a minimal metric set would enable more standardisation of the literature to facilitate real benchmarking between different BiOCl formulations. The third one is the intermediate destiny. Oxidised oligomers, dissolved acids and desorbed co-contaminants will be introduced into the treated water. It is encouraging to note that treated water was acceptable for irrigation in one phytotoxicity test, but this is not necessarily a generalisation; the use of effluents for ecotoxicological testing should be become a standard reporting requirement instead of an optional. The fourth is the outdoor validation. The majority of performance data are generated under artificial lighting conditions under a fixed light intensity. The kinetics are subject to real sun light changes throughout the day, and from season to season. Reactor studies, relating the degradation rate to real-time irradiance in outdoor systems, are relatively limited, and until this information becomes available, projections of the full-scale performance are based on extrapolation.

X. Conclusion

Bismuth oxychloride is a sought-after platform for the photocatalytic degradation of micro-plastics in aquatic systems with a well-founded chemical basis. Its layered structure creates an internal electric field which separates the photogenerated carriers effectively, the surface can be modified to include hydroxyl groups that catalyse polymer oxidation and, given its low cost and lack of toxicity, it is a possible treatment material instead of an interesting one. However, solar activation is not a material property that the material has. Clean BiOCl absorbs only the ultraviolet component of sunlight, about 3-5% of the incident energy, and will require modification, either through facet control, vacancy engineering, heterojunction formation or hydroxylation of the surface, before sunlight can provide a suitable drive. The surface hydroxylation strategy resulted in a 24-fold increase in mass loss, the morphology control strategy combined with the pre-treatment procedure resulted in a gain of 8.8-fold and 6.9-fold of mass loss, respectively, and engineered heterointerfaces led to significant improvements for visible-light activity. However, the absolute degradation under UV light is still relatively low: for typical experimental times, area reductions of about 10% for bismuth-based systems, and even slower for mineralisation. The most defensible application of solar-activated BiOCl is thus as a destructive polishing step in the microplastic concentrates following physical separation, over hours not minutes, and measured in terms of mass loss and CO_2 evolution as well as in terms of particle counts. In that context, the technology solves the one problem that the traditional methods of treatment haven't been able to solve: The irreversible destruction of the particle; and the same material can be engineered such that it can be driven by sunlight.

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