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Breathe free

How to use photocatalytic mitigation
of construction pollution to clean air
and save lives

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Executive Summary

- *Air pollution is a killer and construction is a part of the problem.* Nitrogen dioxide is a major part of the problem with as many as 5,000 deaths per year. In turn, construction equipment is responsible for seven per cent of the problem in places like London.
- *A readily available solution could halve the problem.* Using titanium dioxide on construction hoardings might reduce construction emissions of nitrogen dioxide by up to 50 per cent.
- *Construction equipment does not get replaced quickly.* With very high costs, builders typically hang on to machinery for up to 20 years. Change therefore risks being very slow.
- *National regulation, the Greater London Authority and local authorities and the British Standards Institute could all start the process immediately to mandate or strongly encourage the use of titanium dioxide on construction hoardings.* They should.

The Problem

As many as 5,000 people die each year from nitrogen dioxide (NO₂) pollution in the UK.¹ Its health implications could cost the taxpayer more than £9bn by 2035.² Despite this staggering impact, some of the most significant contributors to NO₂ continue largely uncurbed.

One major offender is construction. Construction contributes to nitrogen oxides³ (NO_x) pollution through what is known as 'non-road mobile machinery' or NRMM. NRMM means powered construction equipment such as generators and diggers. They are largely diesel fuelled and they belch NO_x in their exhaust fumes.⁴

¹ <https://www.eea.europa.eu/publications/air-quality-in-europe-2021/health-impacts-of-air-pollution> Map 3

² https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/708855/Estimation_of_costs_to_the_NHS_and_social_care_due_to_the_health_impacts_of_air_pollution_-_summary_report.pdf p.6

³ Air pollution studies typically measure for nitrogen oxides (NO and NO₂). Although nitric oxide (NO) is not harmful, it readily reacts with oxygen or ozone in the air to form nitrogen dioxide.

⁴ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/792651/red_diesel_summary_of_responses_web.pdf p.5

London is a global leader in the regulation of construction pollution.⁵ However, it remains responsible for seven per cent of central London's NOx pollution.⁶ NRMM is among the capital's worst emitters: a compliant forklift truck in one of London's most stringent zones can emit three times more NOx per mile than a London bus.⁷ Outside London, a heavy duty versatile forklift (a Stage III rated heavy duty forklift) emits twice as much NOx per mile again.

Construction is arguably chronically underregulated at a national level. DEFRA's 2023 Air Quality Strategy alludes to a future NRMM decarbonisation strategy.⁸ However, the report places responsibility firmly with local authorities.⁹ Campaigners, such as the Centre for Low Emission Construction affiliated with Imperial College London, have argued that this was wasted opportunity.¹⁰ Only last year did the UK government stop subsidising diesel for construction.¹¹

We may no longer be incentivising these gas-guzzlers, but we are a long way from switching to green alternatives. Londoners will need to wait until 2040 before electric NRMM is mandatory and at a national level there is no longstop.¹² It is time we got to grips with construction pollution and avoided needless death. Thankfully there's a painless mitigation strategy we could implement tomorrow. This paper argues that we should and shows how.

The Technology

Titanium dioxide (TiO₂) is something of a wonder compound. When TiO₂ interacts with NOx it transforms these pollutants into harmless nitrates. This interaction occurs because TiO₂ is a photocatalyst: in other words, sunlight excites electrons in the material which react with these gases.¹³

TiO₂ coatings have been tested for their potential to mitigate NOx pollution. DEFRA, in their Local Air Quality Management support guidance, describe this technology as 'innovative' and point to successful trials in Italy and China, which achieved a 50 per cent reduction in ambient NOx concentrations.¹⁴ However, DEFRA also temper expectations, pointing to inconclusive trials in

5 <https://www.london.gov.uk/press-releases-6257>

6 <https://data.london.gov.uk/download/london-atmospheric-emissions-inventory--laei--2019/17d21cd1-892e-4388-9fea-b48c1b61ee3c/LAEI-2019-Emissions-Summary-including-Forecast.zip> NOx Summary, Year 2019, GLA Central

7 All TFL buses are Euro VI compliant as of 2021. NRMM in London's Central Activities Zone and Opportunity Areas needs to meet Euro IV as per reference above.

8 <https://www.gov.uk/government/publications/the-air-quality-strategy-for-england/air-quality-strategy-framework-for-local-authority-delivery> Section 4.3

9 Ibid. Actions for local partners: 9

10 <https://twitter.com/ConstructDustUK/status/1649415804457238533>

11 <https://www.gov.uk/government/publications/reform-of-red-diesel-entitlements/reform-of-red-diesel-and-other-rebated-fuels-entitlement>

12 <https://www.london.gov.uk/programmes-and-strategies/environment-and-climate-change/pollution-and-air-quality/nrmm> Future changes to the standards

13 <http://nathan.instras.com/documentDB/paper-236.pdf>

14 <https://laqm.defra.gov.uk/faqs/faq42/>

Camden and the City of London.¹⁵

An Imperial College report argues that not too much consequence should be given to these trials. In a survey of global research, it notes that both used only a small area of coating.¹⁶ It goes on to posit that small areas of coating are inadequate to sufficiently reduce NOx.¹⁷ Instead, Imperial's report includes trials such as a 2014 study which showed TiO₂ coatings could reduce NOx levels by around 28 per cent.¹⁸ The coatings, the same report found, are particularly effective in mitigating NO: the most active achieved a 95 per cent reduction in the gas in real world, outdoor conditions.¹⁹

Although the London trials may have dampened initial adoption at home, the potential of photocatalytic mitigation to deal with air pollution has not gone unnoticed overseas. Notably, Italy has led the way in deploying this technology. Recent applications include TiO₂ treated fins on the 40,000m² San Raffaele Hospital which opened last year, and a treated façade on the Palazzo Italia — the host's pavilion for the 2015 Milan Expo.²⁰

A Possible Solution

We propose using TiO₂ coatings on construction hoardings to mitigate the dangerous NOx emissions from building sites. Two London trials, one piloted by Sir Robert McAlpine, and another by Wilmot Dixon, have deployed these coatings on their hoardings, showing a promising new application for this technology.²¹



Pilot of TiO₂ coatings on construction hoardings, London. (Photo: Author's own)

¹⁵ Ibid.

¹⁶ <https://eic-uk.co.uk/media/baecbnd4/towards-purer-air.pdf> p.31

¹⁷ Ibid. p.32

¹⁸ Ibid. p.21

¹⁹ Ibid.

²⁰ <https://www.dezeen.com/2022/04/26/mario-cucinella-architects-san-raffaele-milan-architecture/> and <https://www.dezeen.com/2014/05/13/italy-milan-expo-pavilion-nemesi-air-cleaning-facade/>

²¹ <https://constructionmanagement.co.uk/willmott-dixon-uses-air-purifying-paint-at-london-site/> and <https://www.srm.com/news-and-comment/innovative-solutions-to-reduce-air-pollution-around-moorgate/>

Construction hoardings are perimeter fences that surround building sites. They are typically made from timber and often screened with marketing and branding. Already an industry standard, they are an existing structure ideally situated to filter construction pollution before it reaches the surrounding area. By coating these hoardings in TiO₂ we can protect local residents and passers-by.

In addition to their ideal situation, construction hoardings also offer a sufficient area for coating. A typical 2.4m hoarding around a development site for 50 homes would offer a considerable 2,100m² of surface for coating.²² That compares to 135m² of coating at the small-scale and disappointing Camden trial. Although only the largest commercial developments require this length of hoarding, the density of building sites in cities would quickly cumulate thousands of meters of surface for TiO₂ coatings.²³ Every urban dweller can attest to the number of construction sites and hoardings they pass daily.

Although hoardings are exposed to a high level of wear and tear, these coatings are resilient. They can be washed without reducing the efficacy of the reaction, and the next generation of products might even withstand being scuffed by sandpaper and splashed with oil.²⁴ A further advantage of TiO₂ is it doesn't get 'used up' during its reaction with NO_x. As with all photocatalytic materials, the effect is permanent.²⁵ This means that TiO₂ coatings could be deployed on reusable hoardings as well as sacrificial ones and continue to perform throughout the lifespan of the panel.

Such *photocatalytic mitigation* of construction pollution is a promising new strategy to reduce harmful NO_x levels: applying them to hoardings offers an easy, practicable way to target these emissions at one of their principal sources.

Means of Action

Although there are two documented uses of TiO₂ coatings on construction hoardings in London, they are separated by four years, and there is no publicity suggesting another is upcoming. With no regulation or incentivisation, adoption has been slow, and the scant developers who have employed photocatalytic mitigation have only done so on single high-profile sites. Raising awareness will help, but is probably insufficient. We propose three ways to make it happen.

²² Development assumed at 41 dwelling per hectare (CPRE's 2019 figure for the average minimum density assumption on brownfield register sites)

²³ The building site of 1 Undershaft, London's to-be second tallest skyscraper, would offer ~2000m² of hoarding surface for treatment, assuming a 2.4m hoarding around the site perimeter.

²⁴ <https://www.imperial.ac.uk/news/164307/new-paint-makes-tough-self-cleaning-surfaces/>

²⁵ <https://www.sciencedirect.com/topics/engineering/photocatalysis>

Regulation

In his latest annual report on air pollution, the Chief Medical Officer Sir Chris Whitty notes that effective action can be taken immediately to deal with the construction industry's emissions, but that these efforts would be best underpinned by regulation.²⁶ Although he is writing in the context of decarbonisation, photocatalytic mitigation might be the faster way for regulators to improve air quality.

One of the challenges that Sir Chris notes in his report is that a lot of NRMM construction equipment has a long useful lifespan. Generators, for example, last roughly twelve years; tower cranes last closer to twenty years. In other words, polluting old fashioned equipment tends to 'hang about.' Waiting for new equipment is a long game. To create a level playing field, any change to standards must therefore be signalled in advance.²⁷ Penalising businesses who have recently invested in equipment could particularly impact the already struggling SME sector.²⁸ With a real urgency to tackle air pollution, what other policies might have a more immediate effect?

Unlike replacing expensive equipment, a requirement to use a TiO₂ coating requires low capital outlay: the D-Tox Guard product used by Sir Robert McAlpine at 21 Moorfields costs £6/m².²⁹ Making photocatalytic mitigation mandatory on building sites in certain locations or above a certain size would be the quickest, least disruptive way to regulate construction pollution.

Planning Process

In addition to regulatory measures, change could also be initiated at the local level. Proactive authorities have pioneered new ways to tackle air pollution. Many of their approaches could easily incorporate photocatalytic mitigation.

One region which has led the way is West Yorkshire, where the Combined Authority, local authorities and Public Health England have jointly developed a Low Emissions Strategy.³⁰ This includes an Air Quality and Planning Technical Guide.³¹

Not only does this guide nudge applicants towards better practice by flagging the impact of development on air quality. It also sets out the case for planners to consider the level of proposed mitigation when determining an application. Any proposed mitigation is then guaranteed through the planning process either by the mechanism of conditions or the use of Section 106 agreements.³² Grounding this approach, the Guide, quite reasonably,

²⁶ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1124738/chief-medical-officers-annual-report-air-pollution-dec-2022.pdf p.162

²⁷ Ibid.

²⁸ <https://www.theconstructionindex.co.uk/news/view/business-is-worse-now-than-during-pandemic-says-construction-smes>

²⁹ <https://www.guardindustry.be/en/dtoxguard-ext.html>

³⁰ <https://www.bradford.gov.uk/media/3590/west-yorkshire-low-emissions-strategy.pdf>

³¹ <https://www.bradford.gov.uk/media/3591/air-quality-and-emissions-planning-guide.pdf>

extends the criteria of 'sustainable development' — a core concept in the National Planning Policy Framework³³ — to include air quality, affirming it as a material consideration.³⁴

While this guide primarily focusses on dust pollution when discussing construction, it shows the effectiveness of such documents and how city or local authorities can incorporate, if not mandate, photocatalytic mitigation. The Greater London Authority (GLA) particularly should incorporate this as soon as possible.

Standards

A final approach to drive photocatalytic mitigation uptake would be to create a new British Standard for TiO₂ coating products. British Standards are published by the British Standards Institute (normally known as the BSI), the national standards body. They provide specifications and guidelines for everything from travel adaptors to structural steel. They are widely used to assure quality, safety and reliability.

Bodies in the construction industry issue guidance on hoardings. Most, including the guidance issued by the National Federation of Demolition Contractors³⁵ and the Temporary Works Forum³⁶, is developed with reference to British Standards, such as BS 5975:2019 (Design Temporary Falsework) and BS6180:2011 (Barriers in and about buildings. Code of practice). This is to ensure it sits within a rigorous and implementable framework. With a British Standard, the use of TiO₂ coatings could be integrated into these guidelines and become part of standard industry practice relatively quickly.

These guidelines have safety at their heart: they ensure hoardings do not fail and cause injury, and that they offer adequate protection for individuals and crowds from building sites. Referencing our proposed British Standard, these guidelines could be expanded to also mitigate the public health risk of air pollution.

Conclusion

In April air quality monitoring data revealed that every London borough is in breach of the WHO's recommended limit for ambient NO₂.³⁷ The UK statistic for average urban background levels of NO₂ also exceeds the guideline.³⁸

³² Ibid. p. 14

³³ <https://www.gov.uk/guidance/national-planning-policy-framework/2-achieving-sustainable-development>

³⁴ <https://www.bradford.gov.uk/media/3591/air-quality-and-emissions-planning-guide.pdf> Foreword

³⁵ https://www.citb.co.uk/media/xepdpxp5u/temporary_works_hoardings.pdf

³⁶ https://www.temporaryworks.info/TWf/TWf2012_01_Dec13_Hoardings_good_practice.pdf

³⁷ <https://www.london.gov.uk/New%20highly%20localised%20data%20shows%20every%20borough%20in%20London%20exceeds%20World%20Health%20Organization%20limits%20for%20toxic%20pollution>

³⁸ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1153246/Table01.csv/preview Urban Background, 2022

Although street tree planting, the transition to active travel, electric cars and the implementation of low emissions zones are starting to help, the crisis is far from over.



Author's design for a reusable panel for construction hoardings. The articulated design increases the available surface area for TiO₂ coatings

Photocatalytic mitigation of construction pollution could be an important and relatively pain-free weapon in the fight for clean air. National regulation, the Greater London Authority, local planning authorities and the BSI could make this happen relatively quickly. They should start the process immediately to clean the air and save lives.

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