INTRODUCTION

The chemistry of the indoor environment remains poorly understood, specifically the contribution of heterogeneous surface reactions and their role in oxidation chemistry. Given that humans spend a large proportion of their time indoors and a number of indoor oxidants exist, it is critical to fully understand oxidation chemistry and how it affects the composition of indoor air. Heterogeneous surface chemistry is thought to play a significant role in indoor chemistry owing to the large indoor surface-to-volume ratio. Indoor radiation is typically emitted with wavelengths >320 nm, which suggests that common photochemical processes that are induced by sunlight outdoors will not occur readily indoors. However, the presence of photocatalytic material in indoor paints may allow photochemical reactions to occur at wavelengths of light that are present indoors. One such potential reaction is the heterogeneous photooxidation of NO to HONO. NO(g) is commonly found indoors, originating from combustion sources, ventilation and infiltration of outdoor air. We studied the interaction of NO(g) with painted surfaces illuminated with indoor fluorescent and incandescent lighting. There is a loss of NO(g) to painted surfaces in the dark at both 0 and 50% RH. At 50% RH, there is a re-release of some of that NO(g) under illumination. The same behavior is observed for illumination of different colored paints. This is in contrast to what is seen with TiO2 as the substrate, where photoenhanced uptake of NO(g) and formation of NO2(g) are observed. We hypothesize that the loss of NO(g) is due to adsorption and diffusion into the paint. The re-release of NO under illumination is thought to be due to photooxidation of NO to HONO on the painted surface at higher relative humidities and subsequent HONO photolysis.

KEYWORDS
HONO, indoor illumination, NO, paint, photochemistry, surfaces

1 | INTRODUCTION

Heterogeneous surface reactions play a key role in the chemistry of the indoor environment because of the large indoor surface-to-volume ratio. The presence of photocatalytic material in indoor paints may allow photochemical reactions to occur at wavelengths of light that are present indoors. One such potential reaction is the heterogeneous photooxidation of NO to HONO. NO(g) is commonly found indoors, originating from combustion sources, ventilation and infiltration of outdoor air. We studied the interaction of NO(g) with painted surfaces illuminated with indoor fluorescent and incandescent lighting. There is a loss of NO(g) to painted surfaces in the dark at both 0 and 50% RH. At 50% RH, there is a re-release of some of that NO(g) under illumination. The same behavior is observed for illumination of different colored paints. This is in contrast to what is seen with TiO2 as the substrate, where photoenhanced uptake of NO(g) and formation of NO2(g) are observed. We hypothesize that the loss of NO(g) is due to adsorption and diffusion into the paint. The re-release of NO under illumination is thought to be due to photooxidation of NO to HONO on the painted surface at higher relative humidities and subsequent HONO photolysis.

KEYWORDS
HONO, indoor illumination, NO, paint, photochemistry, surfaces
to human health (eg.\textsuperscript{6,7}). It is present indoors from combustion activities such as cooking, wood-burning fires, candles and cigarette smoke,\textsuperscript{8,10} and ventilation and infiltration of outdoor air. Peak indoor NO(g) concentrations are between tens to hundreds of ppbv,\textsuperscript{6,11} During periods of activity such as cooking, NO(g) concentrations increase; for example, in a study in a New York residence, an increase in background concentration by two orders of magnitude was observed.\textsuperscript{8} It is likely that NO will undergo a number of transformations indoors such as uptake to surfaces, reaction with other gaseous species, and heterogeneous reactions on surfaces, given the complexity of the indoor environment.\textsuperscript{12} Numerous heterogeneous photosensitized reactions involving adsorbed reagent compounds have been demonstrated outdoors at wavelengths >320 nm,\textsuperscript{13} and similar reactions could occur in the presence of indoor lighting. Therefore, it is likely that NO\textsubscript{2}(g) will undergo heterogeneous surface photochemistry and could influence the oxidation chemistry of the indoor environment. In our previous study\textsuperscript{2} of nitrate photochemistry on indoor painted surfaces, HONO was detected from nitrate surface photochemistry using common indoor illumination sources. HONO has the potential to affect indoor oxidation chemistry because it forms the OH radical via photolysis at wavelengths available indoors.\textsuperscript{14}

Building on this earlier work, here we report an investigation into the interaction of gas-phase NO with surfaces painted with commercial interior paints, under indoor illumination. The paints that we investigate are not advertised as being photocatalytic by the manufacturer although we note that paints marketed as being photocatalytic appear to have more prevalence in the European market. Typically, paints marketed as being photocatalytic contain nanoscale TiO\textsubscript{2} and are distinguished from those containing microscale TiO\textsubscript{2}, which is used for pigmentation.\textsuperscript{15,16}

Some previous studies concerning interactions of NO\textsubscript{2}(g) and painted surfaces have focussed on the photocatalytic efficiency of the paint, that is, how well certain gaseous compounds are removed from the environment, and have considered the effect of illumination source and substrate, whereas others have focussed on improving the photocatalytic efficiency.\textsuperscript{16-22} Topalov et al.\textsuperscript{17} studied the photocatalytic efficiency of plasterboard painted with a base coating of orange acrylic paint with an additional coating of an aqueous TiO\textsubscript{2} solution. Samples were illuminated by several different lamps in an experimental chamber, approximately 10 m\textsuperscript{3} in volume to determine the effect on NO\textsubscript{2}(g). They reported a range of efficiencies for the removal of 200 ppb NO via interaction with the illuminated paint from 97% removal under illumination by fluorescent tubes to 30% removal under LED lighting. Gandolfo et al.\textsuperscript{18,19} looked at the effect of TiO\textsubscript{2} content in photocatalytic paints as well as the influence of wall temperature on the removal of NO\textsubscript{2}(g) and found that increasing the TiO\textsubscript{2} content resulted in increased NO\textsubscript{2} removal as well as the formation of gaseous HONO and NO. Increasing the wall temperature resulted in increased uptake of NO\textsubscript{2} up to a temperature of 305 K, above which the NO\textsubscript{2} removal efficiency remained constant. At 296 K, only paints containing 7% TiO\textsubscript{2} resulted in HONO formation, whereas with an increase in temperature to 305 and 313 K, paints with 0%, 3.5%, 5.25%, and 7% TiO\textsubscript{2} also released HONO with illumination. Salthammer and Fuhrman\textsuperscript{21} looked at the degradation of several compounds including NO\textsubscript{2} using three types of photocatalytic paint and one non-photocatalytic paint applied to window glass. They observed degradation of NO\textsubscript{2} with both the non-photocatalytic and photocatalytic paint (both containing TiO\textsubscript{2}) when the samples were illuminated with sunlight simulating lamps. They emphasized that photocatalytic paints may result in secondary emissions that could arise from chemistry originating from the paint binder and that further optimization of the paint formula is required to allow such paints to be marketed as truly de-polluting. Gandolfo et al\textsuperscript{23} also posed that photocatalytic paints produce high concentrations of VOCs and thus may indeed produce pollutants rather than remove them, in agreement with other studies that also suggested that photocatalytic paints could be a pollutant source.\textsuperscript{16,21} More recently, Gandolfo et al\textsuperscript{20} have considered the effect of the porosity of photocatalytic paint on indoor levels of NO\textsubscript{2} and HONO. They found that the more porous the photocatalytic paint was, the more the NO\textsubscript{2} was removed and fewer VOCs were produced. VOC production is connected to photodegradation of the organic binder in the paint, and as porosity increases, binder content decreases and so does VOC emission.

The current study focusses on the interaction of ~30 ppb NO(g) with substrates painted with white, red, and green interior paints in the presence of indoor fluorescent and incandescent lighting. The study focusses on NO(g) rather than NO\textsubscript{2}(g) as we observed little change in NO\textsubscript{2}(g) with illumination during preliminary investigations. To the best of our knowledge, studies involving relevant indoor concentrations of NO(g) in the presence of surfaces painted with interior paints not explicitly marketed as photocatalytic by the manufacturer and illuminated with indoor lighting have not previously been considered.

## Practical implications

- Gaseous NO is present indoors from combustion sources and infiltration of outdoor air.
- NO is lost to surfaces painted with interior paints in different colors (not marketed as photocatalytic) and re-emitted under indoor illumination.
- Hypothesize that NO diffuses through the paint in the dark and is photooxidized on the paint surface to HONO which is then photolyzed to release gaseous NO.
- The release of NO from painted surfaces under indoor illumination could affect the oxidative capacity of the indoor environment.

### 2 | EXPERIMENTAL SETUP

The experimental setup has been described previously,\textsuperscript{2} and only modifications will be described here. In an experiment, a sample
substrate was illuminated through a quartz window in the top of a ~280 cm\(^2\) stainless-steel chamber, through which dilute gaseous NO was flowing, and the gaseous NO\(_x\) concentration exiting the chamber was monitored using a chemiluminescent NO\(_x\) analyzer. The NO\(_x\) analyzer does not differentiate between NO\(_2\) and HONO, which means that some or all of the registered NO\(_2\) signal could be due to HONO. Experiments were conducted at 0% or 50% relative humidity (RH) in the chamber, achieved by humidifying a flow of zero air (Messer, Grade 2) using a water bubbler and combining it with a dry flow of zero air which mixed with NO in the chamber and was measured using a 4085 Fisher traceable hygrometer/thermometer/dew point meter.

A typical experiment involved placing a sample into the chamber and admitting a flow of zero air (at the desired relative humidity) which was directed from the chamber into the NO\(_x\) analyzer (Teledyne API T200U) in order to determine "zero NO\(_x\)(g)" concentrations. Once the zero concentrations were stable, a flow of ~30 ppb NO (Praxair, 2.08 ppm NO in N\(_2\), analytical uncertainty \(\pm 5\%) was admitted to the chamber and the concentration allowed to stabilize. Once stable, the sample was illuminated from above through the quartz window with a fluorescent bulb (Philips Energy Saver 60 W replacement 13 W), an incandescent bulb (General Electric 60 W) or a xenon lamp (Oriel 150 W). Fluorescent and incandescent bulbs were selected as illumination sources because they produced the most renoxification (apart from the Xe lamp) during previous experiments on nitrate-doped surfaces.\(^5\) The measured photon fluxes for these light sources were collected 2 cm from the light source (distance from the base of the bulb to the sample surface) and are included in Figure S1 in the SI. NO\(_x\) concentrations were allowed to stabilize under illumination, and then, the light source was switched off. Following stabilization of NO\(_x\) concentrations in the dark, the sample was illuminated again and the cycle repeated. A fan and an IR optical filter (Edmund Optics KG-3, transmits \(\sim 10\%\) light at wavelengths \(>800\) nm) were used to cool the chamber during incandescent illumination to minimize heating effects.

### 3. RESULTS AND DISCUSSION

Figure 1 shows the changes in NO\(_x\)(g) observed when TiO\(_2\) powder is illuminated with a xenon lamp. There is photoenhanced uptake

\[ \text{FIGURE 1} \]
of NO with the simultaneous production of NO₂, at a conversion efficiency of ~30%. The interaction between TiO₂ and NO under illumination from a Xe lamp is well characterized. Similar experiments conducted at 50% RH under UV illumination also observed production of NO₂ and ultimately HNO₃, with measured conversions of 35% for a 40 ppm NO inlet concentration and a 75.5% modeled conversion (initial NO concentration compared to final NO concentration after illumination). Our observation therefore gives confidence that the present experimental setup can quantify heterogeneous chemistry involving NO.

Figure 2 summarizes the main results of this study for painted samples. The NO concentration in the input gas stream is initially established by bypassing the chamber and introducing the dilute NO(g) directly into the NOx analyzer (step 1 in Figure 2). Subsequently, on directing the flow of NO(g) into an empty chamber (step 2), there is a decrease of ~2% in the measured NO concentration compared to that measured in step 1; this is indicative of a small loss of NO to the chamber walls. On bypassing the chamber again, the original concentration in the gas flow is regained (step 3). When a painted sample is added to the chamber (step 4), a clear decrease in the NO concentration is measured, above that seen in the empty chamber, suggesting NO uptake by the sample surface in the dark. This loss amounts to ~15% of the NO concentration present in an empty chamber, and thus, ~85% of the NO concentration present in an empty chamber remains. We note that the exact amount of this loss varied from experiment to experiment by ±2 ppb, but such loss was always present. At the same time, there is an increase in the registered NO₂(g) concentration (which could be due to HONO as mentioned previously): this is not affected by subsequent illumination. We note that, although the registered NO₂ concentration is always seen to increase in this manner, its concentration is close to the detection limit of the analyzer and so quantification is not possible. When the sample is illuminated with an incandescent bulb, ~20% of the NO concentration lost in step 4 is regained, suggesting that illumination causes some of the lost NO to be re-emitted. When the illumination source is switched off, the NO concentration decreases to its previous value again. This process is reproducible, as evidenced by the similar concentrations measured when the illumination cycle is repeated.

Results from illumination of white painted samples illuminated with fluorescent and incandescent lighting are shown in Figure 3 in the upper and lower panels, respectively. The same trend is apparent as observed in Figure 2, of uptake of NO in the dark and some amount of NO re-emitted under illumination. The horizontal gray line represents the NO concentration in an empty chamber (28.7 ± 0.4 ppb), that is, with no sample present. Uptake of NO in the dark was observed for all experiments conducted on painted...
samples and is indicated by comparison of the gray line (concentration in an empty chamber) to the blue line when the sample is in the dark (concentration with sample present). No measurable change in the NO$_2$ concentration was observed during these experiments but there is clearly a small amount of NO$_2$ (or HONO) present as also shown in Figure 2, step 4. Figure S2 shows that there is no loss of NO(g) to an unpainted glass surface, and only a modest loss to an unpainted cardboard surface; the painted surfaces display greater uptake and also release of NO under illumination. As the same trend is seen with both fluorescent and incandescent illumination, it appears that the paint is acting as a photosensitizer when illuminated by light of wavelengths $>320$ nm.

In order to investigate the effect of paint composition, experiments were conducted on brightly colored interior paints in red and green from a different manufacturer. These paints were also not marketed as being photocatalytic. The same trend of NO(g) uptake in the dark with some amount re-emitted under illumination was also observed with these samples, as shown in Figure S3. The amount of NO(g) re-emitted with fluorescent and incandescent illumination for all samples at 50% RH is shown in Figure 4, and an expanded table of experiments is included as Table S1 in the SI.

A number of control experiments were also conducted to determine whether the underlying substrate, sample temperature, or relative humidity contributed to the measured NO$_x$ concentrations. Experiments were performed on unpainted cardboard and glass substrates at 50% RH. No significant change in concentration was observed for illumination of an unpainted glass substrate with a fluorescent bulb at 50% RH, in comparison with the same experiment conducted on white painted glass (Figure S2). However, a change in NO concentration was observed for an unpainted cardboard surface with an incandescent bulb; the painted surfaces display greater uptake and also release of NO under illumination. As the same trend is seen with both fluorescent and incandescent illumination, it appears that the paint is acting as a photosensitizer when illuminated by light of wavelengths $>320$ nm.

No significant change in concentration was observed for illumination of an unpainted glass surface, and only a modest loss to an unpainted cardboard surface; the painted surfaces display greater uptake and also release of NO under illumination. The study conducted by Topalov et al. is particularly relevant to the present study as it considers NO abatement on painted surfaces under indoor illumination. However, the orange acrylic paint studied...
by those authors was additionally coated with a dilute aqueous solution of a commercial sol of photocatalytic TiO₂ (CristalACTIV™ S5-300B, containing ~18% ultrafine TiO₂) to give 6 dry weight % of TiO₂, meaning that their observations while still relevant are not directly comparable with the present study conducted on real commercial paints with no further modification. Topalov et al.17 saw removal of NO under illumination, as we observed when TiO₂ powder was illuminated with a xenon lamp, as displayed in Figure 1. This suggests that when TiO₂ is directly accessible on a surface, uptake of NO and production of NO₂ are observed under illumination. However, when TiO₂ is present in a commercial paint matrix, as is the case in the current experiment and in an indoor environment, uptake of NO in the dark is observed, followed by re-release under illumination.

Regarding uptake of NO in the dark by the painted surfaces, there is evidence to suggest that gases can diffuse through porous and painted surfaces.26,27 A recent study has identified the partitioning of VOCs to indoor painted surfaces and their diffusion through paint.27 Similarly, as mentioned in the introduction, a study investigating the effect of photocatalytic paint porosity on NOx levels has shown that higher levels of NO₂ are removed to painted surfaces that are more porous.20 In addition, there are numerous studies on NOx abatement that report adsorption of NO on to porous zeolite surfaces (eg.24). These studies support our hypothesis that the loss of NO we observe in the dark is due to adsorption by the painted surface and diffusion into the paint. The behavior of the unpainted cardboard sample under incandescent illumination shown in Figure 4 and S2 further supports that NO will diffuse through porous surfaces and be re-released under illumination. Future experiments will explore this further using surface analytical tools.

As already mentioned, the small amount of NO₂ that is observed in the current study when painted surfaces are exposed to NO in the dark may actually be HONO(g), given that our NOx analyzer detects HONO as NO₂. The existence of aqueous reservoir compounds such as HONO on indoor surfaces has been proposed.9,12,28 During a study in a Toronto residence,9 it was noted that the measured HONO concentration was insensitive to changes in ambient gas-phase NO₂ concentrations and thus the authors proposed that indoor HONO concentrations were not controlled by conversion of NO₂ on surfaces. Instead, they suggested that nitrite and/or HONO, formed via uptake of NO₂ to surfaces, could be dissolved in adsorbed waters to form aqueous-phase HONO. In the current study, it is possible that an aqueous HONO reservoir exists on the painted sample surfaces. This could be formed though the heterogeneous photooxidation of NO(g), forming surface nitrite, which could go on to form aqueous-phase HONO under the experimental conditions of 50% RH, as outlined in reaction 6. Collins et al.9 proposed that such aqueous surface reservoir compounds are in equilibrium with the gas-phase, which could provide an explanation for the small concentration of NO₂(g) we observe. To distinguish between HONO and NO₂ in future studies, a denuder will be employed to remove gaseous acids prior to entering the NOx analyzer.

It is well established (and observed in the present study—see Figure 1) that NO(g) undergoes heterogeneous photocatalytic oxidation to NO₂ on TiO₂ surfaces at high enough relative humidity. The chemistry responsible is thought to be:

\[
\begin{align*}
TiO_2 + h_\nu \rightarrow h^+ + e^- & \quad (1) \\
H_2O + h^+ \rightarrow H^+ + HO^\cdot & \quad (2) \\
O_2(ads) + e^- \rightarrow O_2^- & \quad (3) \\
O_2^- + H_2O \rightarrow OH^- + HO_2 & \quad (4) \\
NO + HO_2 \rightarrow NO_2 + HO^\cdot & \quad (5)
\end{align*}
\]

An alternative oxidation, to nitrite, involves the reaction18:

\[
NO_{(ads)} + HO_{(ads)} \rightarrow HONO_{(ads)} or NO_{2(ads)}^{-} \quad (6)
\]

We hypothesize that the observed release of NO(g) from the painted surface under illumination is due to photolysis of adsorbed or dissolved nitrite or HONO which can form NO from photochemistry occurring in the wavelength range of the incandescent and fluorescent lamps used here. Photolysis of nitrite occurs between 200 and 400 nm and results in the formation of NO and OH and so could occur in the presence of indoor lighting as per reaction 7.29,30

\[
NO_{2(ads)}^{-} + h_\nu \rightarrow NO_{(gl)} + O^- \quad (7)
\]

We acknowledge that the photolysis of an aqueous surface reservoir of HONO or adsorbed NO₂⁻ would also release OH either on the painted surface or into the gas-phase, which could also impact on the oxidation chemistry of the indoor environment. However, OH measurements were outside the scope of the current study so we cannot comment further.
Other aqueous reservoir compounds, such as alkyl nitrates or RONO, could exist on the painted surface and be in equilibrium with the gas-phase. RONO has a weak RO-NO bond and can also give rise to NO(g) through photolysis.

\[
\text{RONO(g)} + h\nu \rightarrow \text{RO} + \text{NO}
\]  

Future work will explore the possibility of RONO being formed via reaction on painted surfaces.

4 | CONCLUSION

There is a steady-state loss of NO(g) in the dark to white, red, and green painted glass and cardboard substrates, independent of paint color, relative humidity, or substrate. Concurrent with the NO loss, a small increase in the NO\(_2\)(g) (or HONO) signal is seen. We hypothesize that the reason for the loss of NO(g) is adsorption and diffusion into the painted surface supported by recent evidence for diffusion of VOCs through painted surfaces. Upon illumination of the painted surfaces with fluorescent or incandescent bulbs at 50% RH, a partial recovery of the NO(g) concentration is observed and the NO\(_2\)(g) concentration does not change. Little to no change in the NO(g) concentration is seen with illumination at 0% RH, which implies that the mechanism involves surface photolysis in the presence of water. We propose that surface reservoir compounds could form from the heterogeneous photocatalytic oxidation of NO(g) to adsorbed nitrite or HONO, or reaction of NO with paint components to form adsorbed RONO. The subsequent photolysis of such surface reservoir compounds is hypothesized to give rise to an increase in NO(g) and potentially OH. Future experiments involving surface analysis and OH tracer measurements are proposed in order to gain further mechanistic insight into the illumination of painted surfaces in the presence of NO(g).

In summary, evidence from the literature has been used to support experimental observations to conclude that gaseous NO(g) can adsorb on to non-photocatalytic interior paints of different colors and can diffuse through the paint at 0 and 50% relative humidity. Therefore, indoor painted surfaces have the potential to act as a sink for indoor NO(g). On illumination of these surfaces with indoor lighting at 50% RH, some NO(g) can be re-released into the indoor environment. Therefore, the chemistry of the indoor environment can be affected by illumination of painted surfaces in the presence of gaseous compounds such as NO(g) which are present from cooking or ventilation of outdoor air.

ACKNOWLEDGEMENTS

This work was funded by the Alfred P. Sloan Foundation under the Chemistry of the Indoor Environments program.

CONFLICT OF INTEREST

There are no conflicts of interest associated with this work.

AUTHOR CONTRIBUTIONS

Stephanie Helen Jones: Data curation (lead); Formal analysis (lead); Investigation (equal); Methodology (lead); Project administration (lead); Supervision (equal); Writing-original draft (lead); Writing-review & editing (lead). Florian Philippe René Hosse: Investigation (equal); Software (supporting). Xiaoying Yang: Investigation (equal).

D. James Donaldson: Conceptualization (lead); Funding acquisition (lead); Resources (lead); Supervision (supporting); Writing-review & editing (supporting).

PEER REVIEW

The peer review history for this article is available at https://publons.com/publon/10.1111/ina.12741.

DATA AVAILABILITY STATEMENT

Data are available on request from the authors.

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REFERENCES

1. Young CJ, Zhou S, Siegel JA, Kahan TF. Illuminating the dark side of indoor oxidants. Environ Sci Process Impacts. 2019;21:1229-1239.
2. Weschler CJ, Carslaw N. Indoor chemistry. Environ Sci Technol. 2018;52:2419-2428.
3. Manuja A, Ritchie J, Buch K, et al. Total surface area in indoor environments. Environ Sci Process Impacts. 2019;21:1384-1392.
4. Kowal SF, Allen SR, Kahan TF. Wavelength-Resolved Photon Fluxes of Indoor Light Sources: Implications for NOxProduction. Environ Sci Technol. 2017;51:10423-10430.
5. Schwartz-Narbonne H, Jones SH, Donaldson DJ. Indoor lighting releases gas phase nitrogen oxides from indoor painted surfaces. Environ Sci Technol Lett. 2019;6:92-97.
6. Dennekamp M, Howarth S, Dick CAJ, Cherrie JW, Donaldson K, Seaton A. Ultrafine particles and nitrogen oxides generated by gas and electric cooking. Occup Environ Med. 2001;58:511-516.
7. Touloumi G, Katsouyanni K, Zmirou D, et al. Short-term effects of ambient oxidant exposure on mortality: a combined analysis within the APHEA project. Am J Epidemiol. 1997;146:177-185.
8. Zhou S, Young CJ, Vandenoort TC, Kowal SF, Kahan TF. Time-resolved measurements of nitric oxides, nitrogen dioxide, and nitrous acid in an occupied New York home. Environ Sci Technol. 2018;52:8355-8364.
9. Collins DB, Hems RF, Zhou S, et al. Evidence for gas-surface equilibrium control of indoor nitrous acid. Environ Sci Technol. 2018;52:12419-12427.
10. Wang C, Collins DB, Hems RF, Borduas N, Antiñolo M, Abbatt JPD. Exploring conditions for ultrafine particle formation from oxidation of cigarette smoke in indoor environments. Environ Sci Technol. 2018;52:4623-4631.
11. Xu J, Jiang H, Zhao H, Stephans B. Mobile monitoring of personal NOx exposures during scripted daily activities in chicago. IL. Aerosol Air Qual Res. 2017;17:1999-2009.
12. Abbatt JPD, Wang C. The atmospheric chemistry of indoor environments. Environ Sci Process Impacts. 2020;22:25-48.
13. George C, Ammann M, D’Anna B, Donaldson DJ, Nizkorodov SA. Heterogeneous photochemistry in the atmosphere. Chem Rev. 2015;115:4218-4258.
14. Gligorovski S. Nitrous acid (HONO): an emerging indoor pollutant. J Photochem Photobiol A Chem. 2016;314:1-5.
15. Truffier-Boutry D, Fiorentino B, Bartolomei V, et al. Characterization of photocatalytic paints: a relationship between the photocatalytic properties-release of nanoparticles and volatile organic compounds. Environ Sci Nano. 2017;4:1998-2009.
16. Auvinen J, Wirtanen L. The influence of photocatalytic interior paints on indoor air quality. Atmos Environ. 2008;42:4101-4112.
17. Topalov J, Hot J, Ringot E, Bertron A. In situ NO abatement by photocatalysis—study under continuous NO injection in a 10-m3 experimental chamber. Air Qual Atmos Heal. 2019;12:229-240.
18. Gandolfo A, Bartolomei V, Gomez Alvarez E, et al. The effectiveness of indoor photocatalytic paints on NOx and HONO levels. Appl Catal B Environ. 2015;166-167:84-90.
19. Gandolfo A, Rouyer L, Wortham H, Gligorovski S. The influence of wall temperature on NO2 removal and HONO levels released by indoor photocatalytic paints. Appl Catal B Environ. 2017;209:429-436.
20. Gandolfo A, Bartolomei V, Truffier-Boutry D, et al. The impact of photocatalytic paint porosity on indoor NOx and HONO levels. Phys Chem Chem Phys. 2020;22:589-598.
21. Salthehammer T, Fuhrmann F. Photocatalytic surface reactions on indoor wall paint. Environ Sci Technol. 2007;41:6573-6578.
22. Ao CH, Lee SC, Mak CL, Chan LY. Photodegradation of volatile organic compounds (VOCs) and NO for indoor air purification using TiO2: promotion versus inhibition effect of NO. Appl Catal B Environ. 2003;42:119-129.
23. Gandolfo A, Marque SRA, Temime-Roussel B, et al. Unexpectedly high levels of organic compounds released by indoor photocatalytic paints. Environ Sci Technol. 2018;52:11328-11337.
24. Devahasdin S, Fan C, Li K, Chen DH. TiO2 photocatalytic oxidation of nitric oxide: transient behavior and reaction kinetics. J Photochem Photobiol A Chem. 2003;156:161-170.
25. Ângelo J, Magalhães P, Andrade L, Madeira LM, Mendes A. Optimization of the NO photooxidation and the role of relative humidity. Environ Pollut. 2018;240:541-548.
26. Lisi L, Pirone R, Russo G, Santamaria N, Stanzione V. Nitrates and nitrous oxide formation during the interaction of nitrogen oxides with Cu-ZSM-5 at low temperature. Appl Catal A Gen. 2012;413-414:117-131.
27. Algrim LB, Pagonis D, de Gouw JA, Jimenez JL, Ziemann PJ. Measurements and modeling of absorptive partitioning of volatile organic compounds to painted surfaces. Indoor Air. 2020;30(4):745-756.
28. Wang C, Collins DB, Arata C, Goldstein AH, Mattila JM, Farmer DK. Surface reservoirs dominate dynamic gas-surface partitioning of many indoor air constituents. Sci Adv. 2020;6:1-11.
29. Mack J, Bolton JR. Photochemistry of nitrate and nitrite in aqueous solution: a review. J Photochem Photobiol A Chem. 1999;128:1:13.
30. Chu L, Anastasio C. Temperature and wavelength dependence of nitrite photolysis in frozen and aqueous solutions. Environ Sci Technol. 2007;41:3626-3632.
31. McLaughlin RP, O’Sullivan D, Sodeau JR. Cold-surface photochemistry of primary and tertiary alkyl nitrates. J Phys Chem A. 2012;116:6759-6770.

SUPPORTING INFORMATION
Additional supporting information may be found online in the Supporting Information section.

How to cite this article: Jones SH, Hosse FPR, Yang X, Donaldson DJ. Loss of NO(g) to painted surfaces and its reemission with indoor illumination. Indoor Air 2021;31:566–573. https://doi.org/10.1111/ina.12741