REDUCING FORMALDEHYDE EMISSIONS FROM WATER-BASED COATINGS

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Whether in our personal lives or in business, environmental sustainability is an increasingly high priority. We all must do our utmost to comply with new, more stringent and/or revised regulations in order to leave a healthier plant for the next generation.

Now is therefore the right time to apply products that can reduce the environmental impact of foundry operations.

This article will discuss water-based foundry coatings that are designed to reduce formaldehyde (FH) emissions. In doing so, they support foundries in achieving compliance with the latest EU regulations of FH release emissions in coating drying processes.

INTRODUCTION

All water-based systems are susceptible to the growth of microorganisms, such as bacteria and fungi, which can influence the performance of those systems and lead to significant changes during application. Microorganisms can also impact the health of the operators who use contaminated products.

In order to avoid such effects and protect water-based systems, biocides are included in their composition. In the foundry environment, water-based coatings are the main products that require this type of protection.

The biocides commonly contain FH, which is a powerful antibacterial and antifungal agent. This FH is released under specific conditions, such as those found in coating drying processes, and therefore contributes to the overall FH emissions of the foundry.

This presents a challenge, however, as FH is considered a harmful substance and regulated as such by the EU. The EU regulation on the emission of harmful substances (2008/50/EG) has recently been revised to further reduce allowable FH emission levels from 20mg/m^3 to just 5mg/m^3.

Even foundries with exhaust gas treatment facilities are required to adopt the new limits.

As an example, the revised directive has been translated for Germany as the new TA-Luft regulation, which requires re-adjustments of emissions levels at old and/or existing plants. In many cases, this would lead to investment in new gas treatment systems. The new limits have been in force since Feb. 2020.

Foseco has taken the challenge on board with a new water-based coating that helps foundries reduce their FH release emissions at the point in the process where concentration is highest: the exhaust chimney of the core drying plant.

This article will not discuss FH levels in Foseco coatings as such, however, but the total FH emissions to which the coating drying process contributes.

A COATING FOR REDUCED FH EMISSIONS

Foundries applying water-based coatings are following an established trend away from solvent-based coatings in order to better comply with environmental demands. However, these water-based products require protection against microbiological attack:

Water based coating – BACTERIAL INFECTION – EFFECTS/ACTIONS/ SOLUTIONS

Since the conversion from solvent-based to water-based coatings is happening with increased speed in Europe, it is necessary to direct foundries' attention to the effects of microorganisms on coating performance, which are not usually well known.

Figure 1. Bacteria infected coating in dip tank

Figure 2. Coating remains unmixed in dead areas in dip tank

PERFORMANCE ALTERATIONS IN CASES OF MICROORGANISM CONTAMINATION

- Smell
- pH drop
- Increased sedimentation
- Poor flow properties
- Reduced edge coverage
- Graphite flotation
- Much stronger coating penetration, leading to core breakage
- Syneresis
- Changed wetting characteristics
- Cracks in coating surface

Figure 3. Syneresis when applying bacteria affected coating

PRODUCT PROTECTION

All Foseco water-based coatings have a built-in biocide that protects the product for the stated shelf life from deterioration due to microorganism growth. However, by diluting with impure water and/or introducing material into the coating that supports the growth of microorganisms over time (e.g., amine acts as fertilizer for bacteria), contamination can still occur.

These biocides remain within the applied wet coating layer and gradually release FH while the coating is dried. In cases when the drying is accelerated by use of drying ovens, FH emission levels tend to be higher in the oven and hence in the oven chimney, where the concentrated gases become of environmental interest.

COATING COMPOSITION

Compared to the rest of the components required for coating manufacturing, the biocide is only a very small proportion (< 0.1%) of the whole, but still contributes to the overall FH level.

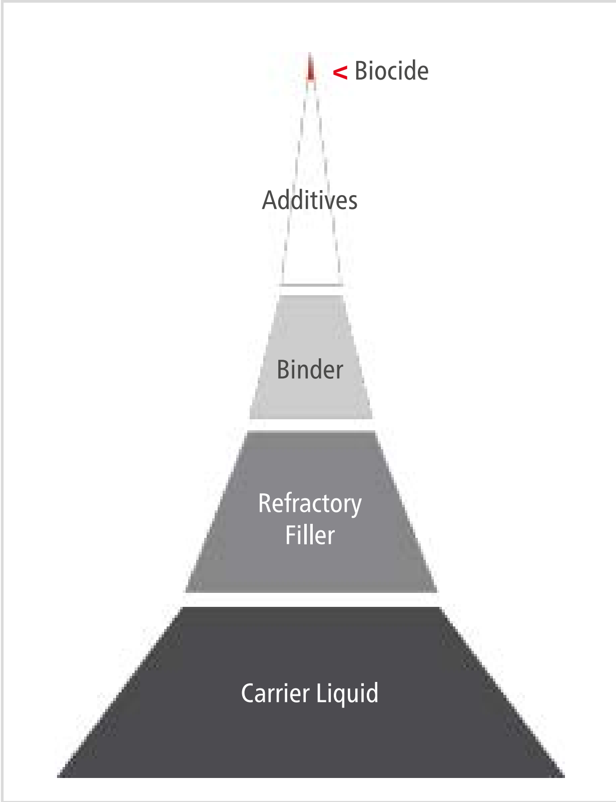


Figure 4. Coating composition

FH EMISSIONS IN FOUNDRIES

During the casting process, various FH emissions occur in a foundry, such as:

- In the melt shop during pouring,
- During shake out, due to decomposed binder components,
- In the core shop during sand/binder mixing, core/mould making and coating drying.

FH is a gas that is unfortunately not easy to measure. This is because of its nature and reactivity with other chemicals and because it might be a reaction product released when a chemical component alters, e.g., during curing, drying, and gassing processes. All those who have assembled flat-pack furniture will know the smell of FH, however, as it is used in many wood-based materials, such as particleboard, as well as many textiles.

If we concentrate in the following discussion on the core shop environment only, admittedly a lot of different odours are noticeable. Usually, the air of a core shop is exhausted and possibly treated. It is then commonly released via the chimney to the atmosphere.

For local authorities responsible for monitoring and controlling gas emissions, the exhaust chimney is the major point of concern. Here gas samples at different times and plant loads may be taken to check gas release levels – an expensive and complex process, in which a lot of influences have to be considered.

Figure 5. FTIR test set up

Figure 6. Sample holder transfer to drying oven

For FH in particular, a common industrial standard test does not exist. Foseco therefore had to develop a reliable test method, that would also help to further develop new products.

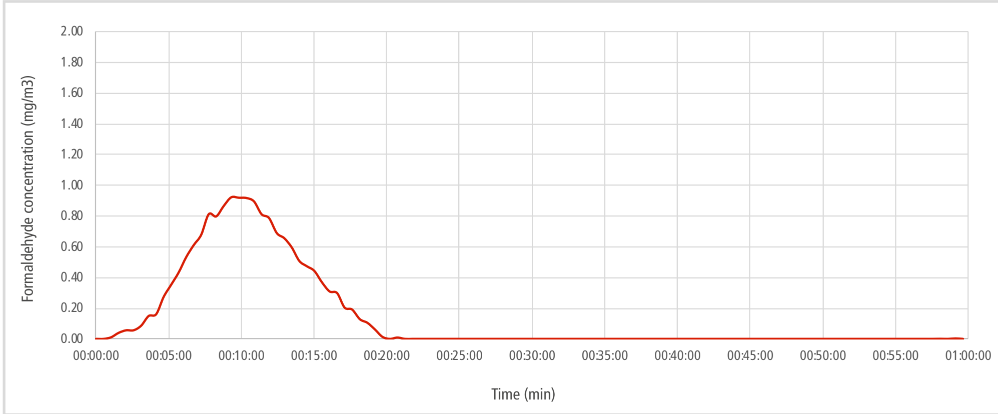
After evaluation of different ways to determine FH emissions, we found FTIR (Fourier Transform Infrared) spectroscopy most suitable, being accurate to the necessary standard and because the equipment is compact.

The test set up consists of a sealed drying oven containing a fixture to hold the sample, a heated exhaust sampler and heated pipes to avoid any condensation. The heated pipes are connected to the gas analyzer, which can then determine different pollutant gas streams, even those that occur concurrently.

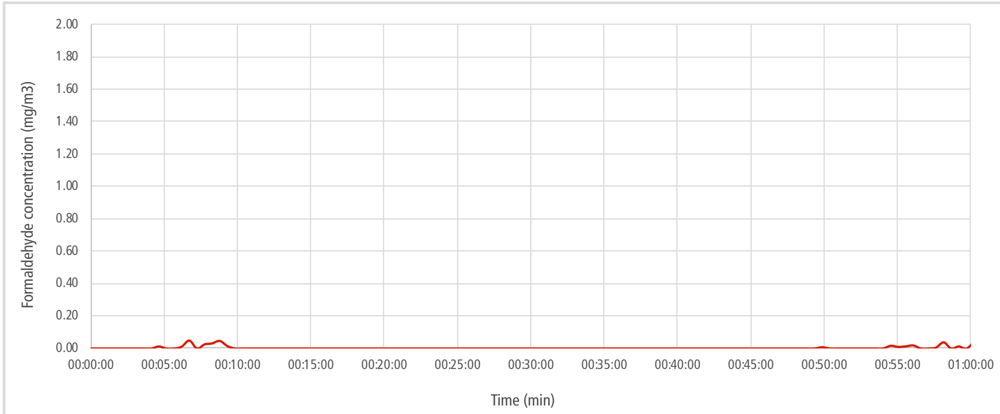
The tests are conducted over a period of 1 hour and enable Foseco to target development of new products.

To help customers to comply with new set limits, our first focus was to develop a coating that does not release FH during the drying period, but still offers the same protection against microbiological attack. During this phase quite interesting observations were made.

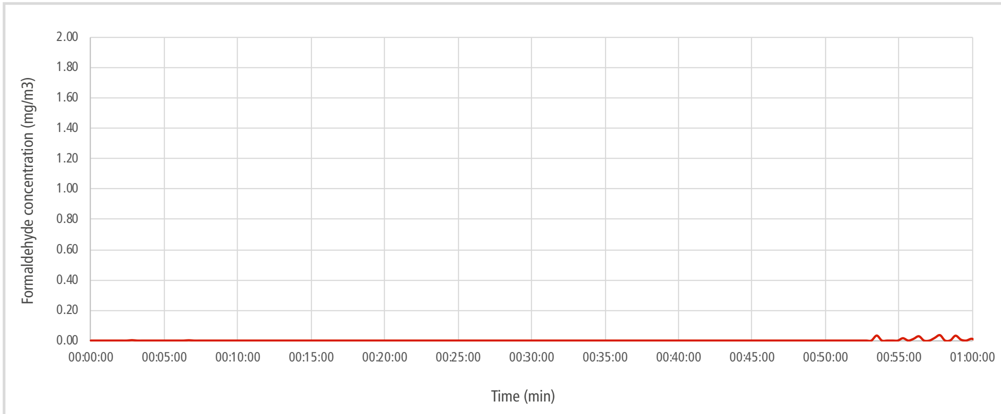
FORMALDHYDE EMISSION PATTERN AT 150°C IN DRYING OVEN



Graph 1: Fresh ColdBox core, as-made

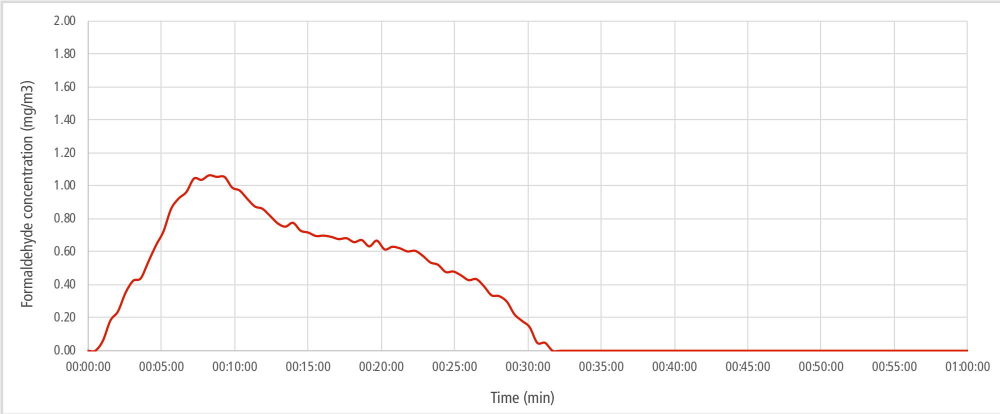


Graph 2: PUCB core aged for 3 days

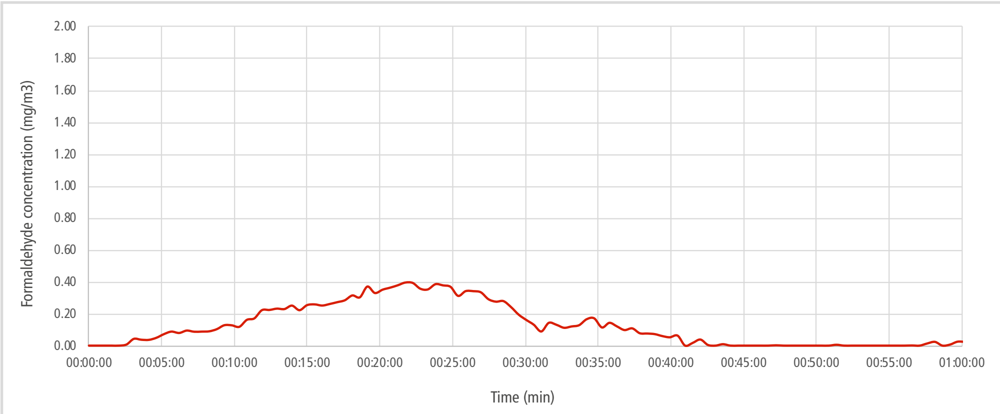


Graph 3: PUCB core aged for 11 days

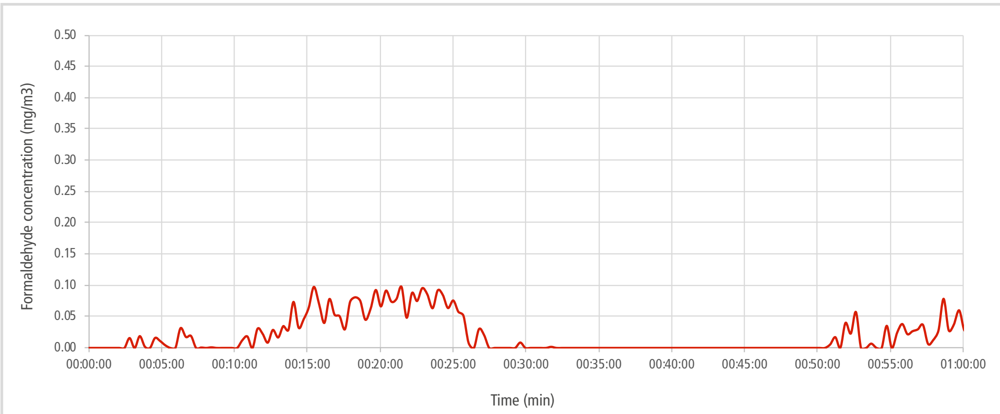
Only the freshly-made core releases a significant contribution to overall FH emissions. The binder related FH emissions observed in the drying oven are impacted significantly by the core storage duration



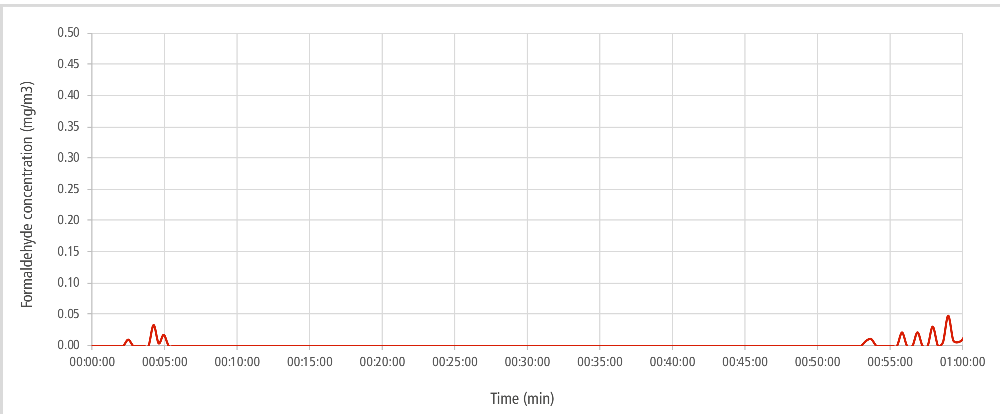
Graph 4: FH emissions from fresh, as made PUCB core with standard coating



Graph 5: FH emissions from fresh, as made core with new SEMCO FF coating



Graph 6: FH emissions from cores aged for 11 days with standard coating



Graph 7. FH emissions from cores aged for 11 days with new SEMCO FF coating

CONCLUSION

Beside the applied coating, there are quite a number of other FH-releasing items in a core shop, such as binders and additives, that contribute to the overall FH emissions. On top of this, during several process steps, e.g., core blowing, drying and storage, FH can be released by components that reassemble / restructure / convert to different chemicals and set FH free as a step in this alteration process.

During the above FH investigation, it became obvious that the new SEMCO FF generation of coatings is only the very first step for modern water-based coatings that will help foundries to comply with the latest EU regulatory requirements.

The next step for coating development will be to evolve the coating into a FH barrier, where the FH-free coating actually absorbs FH released from the sand binder or additives.

All this is combined with a final opportunity to optimize the drying process by incorporating colour change on drying technology. This quickly and easily allows core shop operators to see when the drying process is complete, optimising energy consumption and hence reducing costs and the carbon footprint of core shop operations.

REFERENCES

All work mentioned in this paper was undertaken in Foseco laboratories and represents the results of those investigations.

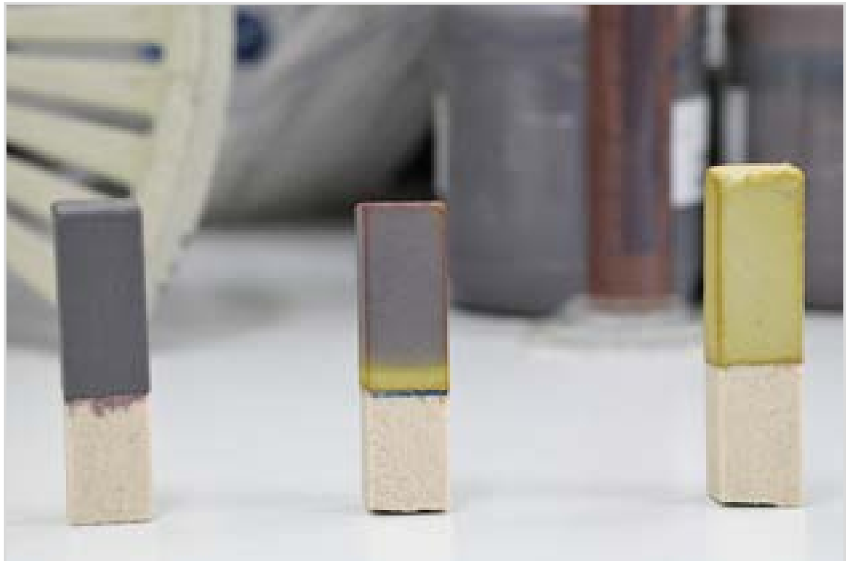


Figure 7. Coating colour change on drying

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