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Improving the Impact of Commercial Paint on Indoor Air Quality by Using Highly Porous Fillers

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Abstract: In the current paper, the effect on Indoor Air Quality (IAQ) of two commercial acrylic-based paints were compared: one (Paint A) for indoor applications, the other (Paint B) for indoor/outdoor applications. Both were applied on an inert and on a real mortar substrate. The possibility of Paint B to passively improve IAQ was also investigated when adding highly porous adsorbent fillers, both as addition or as total replacement of a conventional siliceous one. The obtained results show that all paints have high capacity to inhibit biological growth. Paint A is more breathable and it has a higher moisture buffering capacity. Paint B negatively modifies the beneficial properties of the mortar substrate for IAQ. However, the use of unconventional fillers, especially as addition to the formulation, allows the recovery of the same properties of the substrate or even the enhancement of about 20% of the ability to adsorb volatile organic compounds (VOCs) under the current test conditions.

Keywords: paint; Indoor Air Quality (IAQ); building materials; microbial risk; water vapor permeability; moisture buffering; depollution

1. Introduction

The building sector consumes about 40% of global energy [1]. The tendency in industrialized countries to reduce energy consumption has been accelerated by the European Community (EC) Member States since the introduction of the 2002/91/EC directive [2]. The directive fixes the minimum requirements which have to be respected in new and renovated buildings, with the aim of reducing energy consumption caused by air-conditioning [3]. As a consequence, buildings are more air-tied and the indoor air quality (IAQ) gets inevitably worse and unhealthier, if an adequate air change is not guaranteed [4].

People spend more than 80% of their daily life in indoor environments, such as houses, offices, trains, shopping malls, etc. [5]. Indoor pollutants such as Volatile Organic Compounds (VOCs) and nitrogen oxides (NOx) are emitted by a great number of indoor sources e.g., floor coverings, paints, wood-based furnishings, and cleaning products, as well as cooking, combustion and tobacco smoking [6]. This may cause health problems such as drowsiness, headaches, sore throat, and mental fatigue [7]. On this basis, the removal of VOCs and/or NOx has become of interest to improve IAQ.

Thanks to their high exposed surface in indoor applications, building materials such as mortars, plasters, and finishes can interact with the indoor microclimate as passive systems, therefore increasing IAQ without any energy demand [8–13].

In particular, polymer-based coatings, especially water-based acrylic resins, are widely used as final coatings to protect surfaces against scratches, wear and tear, corrosion and weathering in buildings both for indoor and outdoor applications [14].

Additionally, nowadays, photocatalytic self-cleaning and "depolluting" materials have been suggested as a remediation technology mainly for NOx and VOCs in urban areas. Depolluting activity in passive building materials can be promoted by two different processes: adsorption and Photocatalytic Oxidation (PCO).

In adsorption, fluid phase components (adsorbates), gaseous or liquid, are transferred on the solid surface (adsorbent). Forces of attraction are established between the adsorbate and the adsorbent; the adsorbate covers the surface of the adsorbent with a molecular layer. Since the adsorption process is focused on the surface of the solid, very porous particles with a wide surface area (300–3000 m^2/g), as the fillers used in this experimentation, are required to obtain high removable efficiency of pollutants [15].

In PCO, the addition of a photosensitive agent such as TiO_2 has been investigated in exterior construction materials and interior materials, such as cement, mortar, tiles, paving blocks, glass and PVC fabric [16]. Photocatalytic paints have been implemented with the aim of decomposing VOCs and NOx, and maintaining surfaces free of bacteria, fungi (self-disinfection) and filth (self-cleaning) [17–20]. The efficiency of nitrogen dioxide (NO_2) removal by indoor photocatalytic paints increases with the TiO_2 content in the range 0–7% [21]. Also nano-ZnO is an efficient photocatalytic self-cleaning agent under light emitted from normal domestic fluorescent lights [22].

Both inorganic and organic fillers, as calcium carbonate, nano-silica, carbon black, ashes, are widely used to increase mechanical performance not only of mortars [23,24], but also of paints, such as wear and scratch resistance, and elongation [25–27]. However, they also open the possibility to obtain coatings with a wide range of new properties such as super-hydrophobicity [28], chemical resistance, and high durability under UV light [29–31]. Nano-dispersion of a surface-functionalized fumed silica into an acrylic paint formulation has shown a very low dirt pick-up due to the nano-roughness created by nano-silica particles in the film [32]. The addition of nano-silica in anti-graffiti coatings decreases the capillary water absorption of substrates (mortars and limestones) without worsening the breathability of substrates [33].

The same photocatalytic as well as antimicrobial effects of coatings are influenced by the type of acrylic dispersion, the type of photocatalytic addition, and by the morphology of surfaces [34]. In particular, porosity, which is related to the concentration of paint components (pigments and extenders) has a positive effect on photo-activity. Latex and acrylic paints are more photoactive than mineral ones because of the larger amount of calcium carbonate. However, high content of calcium carbonate and high porosity make paints prone to self-degradation. Also, the higher presence of potassium sulfate in mineral paints is detrimental for their photocatalytic activity [17]. Polymer-based coatings containing nanostructured TiO_2/Ag-exchanged-zeolite-A composite show better UV and visible light absorption, hydrophilicity, depolluting properties, stability in water, and antimicrobial properties compared to pristine commercial grade polyacrylic latex [35].

Also, temperature and Relative Humidity (RH) are relevant factors for indoor comfort and health of occupants. On the one hand, the temperature of indoor walls affects NO_2 removal since temperatures between 30 °C and 42 °C favour the formation of harmful intermediates like HONO, which produces OH radicals if photo-lysed [36]. On the other hand, the optimal indoor RH is about 50% [37]: lower levels of RH cause discomfort and drying of mucous membranes and skin, whereas higher levels of RH cause discomfort and favour biological growth (molds, bacteria, fungi) [38,39] [40]. Moreover, the application of coating and finishing layers can reduce the moisture buffer performance and water vapor permeability of the wall assemblies [41,42] up to half the value [43].

The World Health Organisation has already published guidelines for IAQ related to humidity and mold [40]. Microorganisms from damp indoor environments can be serious health hazards to occupants because of the production of airborne particles such as spores, allergens, toxins and other metabolites. Several hundreds of fungal and bacterial species can be found in indoor environments, mainly *Cladosporium sphaerospermumn*, *Penicilium chrysogenum*, *Aspergillus niger*, *Aspergillus versicolor*, *Alternaria alternata*, *Stachybotrys chartarum*, and bacteria as large groups of Gram negative bacteria and mycobacteria. In the USA, more than 4.5 million cases of asthma result from exposure to damp and mold with an annual economic cost of about $3.5 billion [44]. The most important factor that influences the growth of mold on building materials is moisture, followed by temperature, exposure time, porosity, density, and obviously biocides. Any non-biodegradable material (such as aluminum) can become a substrate to fungal infestation once painted or wallpapered, depending on the type of paint or wallpaper used. Moreover, a biodegradable material treated with a biocide (biocide-treated plasterboard) offers a partial resistance to fungal growth. The composition of the surface covering applied on building materials is therefore of primary importance when considering the sensitivity of this material to potential fungal infestation [45].

Ability of building materials to improve passively IAQ, especially from a depollution point of view, can be due not only to their photocatalytic activity (PCA), but also adsorption capacity. In literature, many papers have been published on the contribution of the photocatalytic process on the depolluting properties of paints but, to the best of our knowledge, no paper investigates the contribution of the adsorption process on their depolluting ability.

Tittarelli et al. and Giosuè et al. have already investigated the possibility of enhancing the ability of mortars based on inorganic binders to passively improve indoor comfort and health conditions by replacing conventional aggregates (sands/fillers) with unconventional aggregates and biomass waste materials [46–48].

In this paper, the effects of two different commercial acrylic paints, Paint A for indoor applications and Paint B for indoor/outdoor applications, have been compared on IAQ in terms of inhibition of mold growth, water vapor permeability, moisture buffering capacity, and depolluting ability in terms of adsorbent properties.

The possibility of Paint B to passively improve IAQ was also investigated when adding highly porous adsorbent fillers, both as addition or as total replacement of a conventional siliceous one.

Paints were tested on two different substrates: on an inert substrate, in order to isolate the only contribution of the paint on IAQ, and on the pre-mixed mortar where paints are really applied, in order to study the contribution of the whole system render and paint on IAQ.

To investigate how the paints modify the properties of the mortar substrate, unpainted pre-mixed mortar substrate was also tested, as comparison.

2. Materials and Methods

2.1. Materials

Two different types of commercial paints were tested (A and B), both provided by DIASEN® (Sassoferrato, AN, Italy). Both paints are VOCs free according to the declaration reported on the data sheet. Paint A is an acrylic-based paint for indoor applications; Paint B is an acrylic-based paint for indoor/outdoor applications. In the case of Paint B, two different types of unconventional fillers (F1 and F2) were added to the commercial formulation as it is (B-F1, B-F2) or by totally replacing the volume (183 cm^3 for 1 kg of Paint) of the conventional siliceous filler: in this case fillers were added to the only resin (Bresin-F1, Bresin-F2).

F1 and F2 are polar fillers, both with high porosity and specific surface area, used as adsorbent for heavy metals, dyes, oil, and molecular sieves in gas separation processes [49]. Figure 1 and Table 1 provide the grain size distribution curves and the physical characteristics of F1 and F2, respectively.

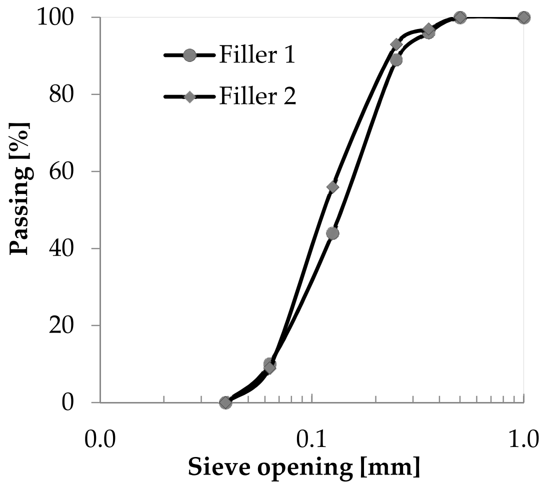

Figure 1. Grain size distribution of fillers.

Table 1. Properties of fillers.

Aggregate	Code	Specific Surface (m^2/g)	Density ssd * (kg/m^3)	Water Absorption after 24 h (%)
Filler 1	F1	750	1310	86
Filler 2	F2	600	1600	22

* ssd: saturated surface dried condition.

Fillers were used in the saturated surface dried (ssd) condition in order to have a minimum modification of the paint rheology by absorbing or releasing water.

When fillers fully replace the volume of the siliceous filler, the fluidity of the paint (Paints Bresin-F1 and Bresin-F2) is not changed. When fillers are added in the formulation, especially F1, the fluidity of the paint (Paints B-F1 and B-F2) is slightly decreased, as shown in Figure 2. However, this fact did not affect the applicability of these paints.

Figure 2. Aspect of Paint B after and before the addition of fillers.

Paints were tested on two different types of substrate: the real substrate and an inert substrate. The real substrate is a pre-mixed mortar commercially available, prepared by adding 26 wt. % of water to the dry ingredients and cured following the data sheet methodology. Different inert substrates were chosen for different test methods, following the suggestions of the corresponding Standards and literature (see Section 2.2. Methods): filter paper, glass filter paper, PVA sheet, stainless steel sheet. Paints were applied on the different supports following the data sheet methodology. After the application, paints were let dry in free air for at least 6 hours before testing.

2.2. Methods

2.2.1. Mold Inoculation

The increasing interest in healthy indoor environments is actually pushing producers and researchers of paints and coating materials to develop products able to inhibit mold growth [50]. The study of molds growth on the tested paints was performed according to UNI EN 15457:2014 using *Aspergillus niger* and *Penicillium chrysogenum*, fungi able to cause health problems including allergies and asthma especially during prolonged indoor exposure.

The strains of *A. niger* (F18) and *P. chrysogenum* (F21) were taken from University of Urbino culture collection and propagated on Potato Dextrose Agar (Oxoid, Basingstoke, UK).

After 7 days of fungal grow at T = 28 ± 0.5 °C, conidia were harvested stirring the culture with a sterile 0.85% NaCl (Sigma-Aldrich, St. Louis, MO, USA) solution containing 0.05% Tween 80 (Sigma-Aldrich, St. Louis, MO, USA) for 5 min. The conidia suspension was gently probed with a pipette tip and filtered to separate conidia from hyphal fragments. The transmittances of the conidia suspensions were adjusted using a BOECO Germany S-30 Spectrophotometer (BOECO, Hamburg, Germany) to provide a final test inoculum of about 10^6 conidia/mL (ODλ530 0.1). 10 µL of conidia solution was placed in the middle of the specimens described above. Only conidia were chosen to perform the inoculum to better reproduce the dynamics of colonization commonly found in nature. The test was performed twice: firstly, specimens were sterilized under gamma radiation (test 1), and then without sterilization (test 2). Following inoculation, the specimens were arranged in Petri dishes containing Potato Dextrose Agar, in order to allow for the possible fungal growth, and incubated for 4 weeks at 25 ± 2 °C and RH = 80 ± 5%.

As the standard indicates, paints were applied on an inert substrate: sterilized filter paper (exposed surface 6.5 cm × 6.5 cm) without biocidal effects. In order to evaluate the effectiveness of the culture, uncoated filter papers were prepared and tested under the same conditions as blank samples.

For each test series three specimens were inoculated. Analyses were conducted by visual observation each week and results expressed as Table 2 shows.

Table 2. Expression of results coming from contamination.

Symbol	Observed Growth on Specimens
-	None
+	Contaminated around the inoculum
++	Widespread contamination

2.2.2. Water Vapor Permeability

Indoor finishes should guarantee a good breathability. They should not hinder the disposal of water vapor of the substrate, immediately after application, and water vapor produced inside the building during its service life, facilitating the drying process [51–53].

The test was performed according to UNI EN 1015-19:2007 and UNI EN ISO 7783:2012 and data processed according to UNI EN ISO 12572:2007. The measurements of water vapor permeability were carried out on paints applied on the real substrate (pre-mixed mortar) and on paints applied on an inert substrate (see Section 2.1). As suggested in UNI EN ISO 7783:2012, glass filter paper is a homogenous and porous material with high water vapor breathability suitable as inert substrate. In order to evaluate how the paints could affect the breathability of the substrate, an uncoated real support (blank) was also tested.

The mortar substrate, prepared as cylindrical specimens (d = 12.5 cm; h = 3.0 cm), was mixed and cured according to the data sheet. Only the uniaxial flux of water vapor was evaluated by sealing the side surface of specimens with a non-breathable film. Paints were then applied on the mortar and on the inert substrate with the same diameter (d = 12.5 cm). After a curing period of 7 days, specimens were placed on the top of a sample holder with a saturated solution of potassium nitrate (KNO_3) inside (RH = 93 ± 3% at T = 20 ± 2 °C) and placed at T = 20 ± 2 °C and RH = 50 ± 5%. The test was conducted until a steady state in mass loss was achieved. For each typology, three specimens were tested and the average results reported in terms of water vapor diffusion resistance factor μ. μ is defined as the ratio between the vapor permeability of stagnant air δ_a (kg/(Pa m s)) and the vapor permeability of the material δ_p (kg/(Pa m s)) at the same temperature and pressure [54].

2.2.3. Moisture Buffering Capacity

Finishes for indoor applications should be designed not only with high permeability, but also with ability to act as a buffer for moisture. The ability of a material to absorb and release moisture from/to the environment was performed according to a simplified version of the NORDTEST method [55] where specimens were cyclically exposed to different RHs for fixed periods of time. Paints were applied and tested on the real support (see Section 2.1) and on an inert support. In this case, a polyvinyl chloride (PVC) sheet, with no Moisture Buffering Capacity (MBC) [55], was chosen as the inert support. In order to evaluate how the paints could change the MBC of the substrate, an uncoated real mortar substrate (blank) was also tested.

Specimens were prismatic in shape (4.0 cm × 16.0 cm × 3.0 cm). The two parallel surfaces (4.0 cm × 16.0 cm) were exposed to different RHs, whereas the side surfaces were sealed with a non-breathable film. Before testing, specimens were placed in a climate chamber at T = 20 ± 2 °C and RH = 50% ± 3% until constant weight was achieved. Then, specimens were exposed to 24 h daily cycles reproducing indoor conditions of high (RH = 75% ± 3% for 8 h) and low (RH = 33% ± 3% for 16 h) RH levels. The two different RHs were reproduced thanks to a saturated solution of magnesium chloride ($MgCl_2$, RH = 33% at T = = 20 ± 2 °C) and of sodium chloride (NaCl, RH = 75% at T = 20 ± 2 °C) placed inside closed boxes. The amount of water vapour absorbed or released by the specimens during each step was measured by weighing the specimens before changing the box [47]. For each type of paint, three specimens were tested and the average results reported in terms of Moisture Buffering Value (*MBV*).

2.2.4. Depolluting Capacity

The possibility of acrylic-based paints to not be only VOCs free [56] but also able to remove indoor VOCs by adsorption has been tested.

Methyl-ethyl-ketone (MEK) was chosen as model for VOC thanks to its environmental stability. This compound is irritant for human eyes and nose and harmful health effects occur at high concentrations, Threshold Limit Value (TLV) = 200 ppm = 590 mg/m^3. The MEK vapour pressure is 95.1 mmHg at T = 25 °C. It has an odour threshold of 5.4 ppm, corresponding to 16 mg/m^3 [57]. Paints were applied and tested on an inert substrate: in this case a stainless steel sheet, with an exposed surface of 7.0 cm × 7.0 cm, was chosen because stainless steel does not adsorb any pollutants and for this reason it is widely used for reactors [58] or chambers [13].

Specimens were placed in a 16.65 L sealed glass box, 50 µL of MEK (corresponding to 2402 mg/m^3) were injected and the concentration of MEK monitored over time [46,47]. Air mixing was ensured by a fan placed on the bottom of the box. The air inside the box was sampled by a micro-syringe and analyzed with a gas chromatograph (Flame Ionization Detector, injector split 1:15, carrier flow He 2 mL/min, capillary column, 25 m × 0.32 mm, 0.52 µm cross linked methyl siloxane, isotherm condition 40 °C). Three measurements were repeated for each type of specimen and the trend line was evaluated. After 120 min of exposing time, the percentage of MEK residual concentration (Ci/C0%) was measured by the ratio between the MEK final concentration (Ci) and the MEK initial concentration (C0).

3. Results and Discussion

3.1. Mold Growth Inibition

During the 4 weeks of testing, the fungal capability to colonize the specimens was evaluated at the end of each week and the results are reported in Table 3. Moreover, Figure 3 reports relevant pictures of specimens at the end of the test (4th week from the inoculum). Despite the effectiveness of the culture (blank specimens show high contamination) and the addition of unconventional fillers, all paints inhibit mold growth confirming the effectiveness of the biocide within the formulation of each paint, as declared by the producer on the data sheet. Furthermore, high levels of resin, comparable to those of the investigated paints, can inhibit the growth of mold, even without the presence of biocides, as reported in previous studies [59].

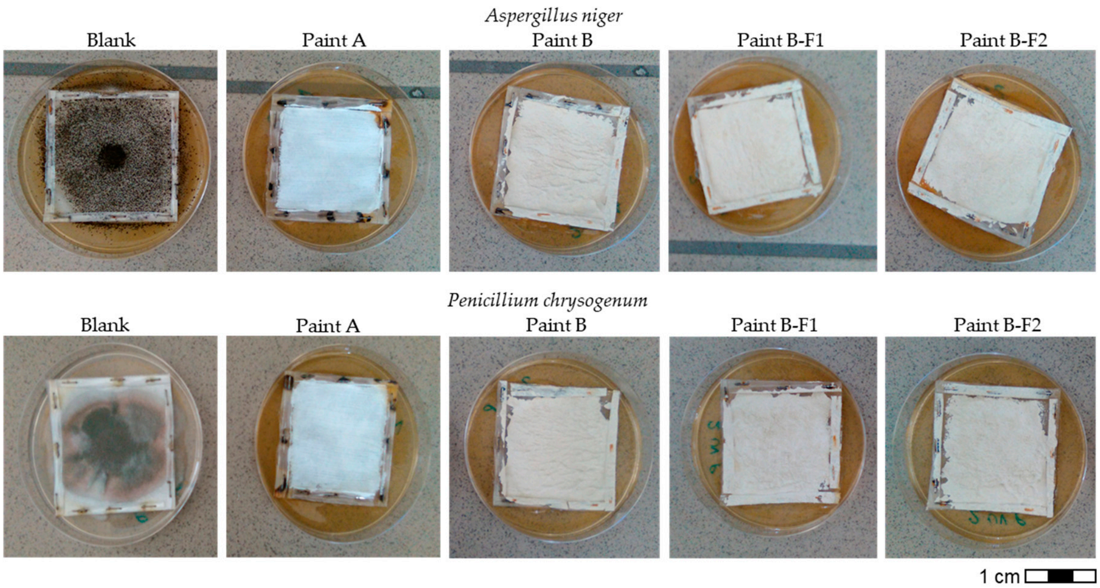

Figure 3. Example of specimens after 4 weeks from the inoculum under test condition 2. Results are the same with and without the previous sterilization of the specimens. All paints appear without fungal colonization.

3.2. Water Vapor Permeability

Figure 4 shows results obtained by the water vapor permeability test in terms of water vapor diffusion resistance factor, μ. The lower the factor, the higher the permeability.

As expected, the lowest value is given by the inert support. The application of Paint A on the inert support implies three times higher μ value. The application of Paint B on the inert support implies a μ value more than ten times higher compared to the inert support.

The real support is a mortar with high breathability if compared to literature values [60]. The application of coatings on porous substrates such as mortars can decrease permeability [43]. The application of Paint A on the real support implies just a 6% higher μ. The application of Paint B on the real support implies two times higher μ. Therefore, Paint B gives the highest value of μ both on real and inert supports.

However, the addition of unconventional fillers in Paint B decreases μ to values comparable to those measured in Paint A.

On the inert support, the addition of F1 in Paint B reduces the corresponding μ of 71%, whereas F2 of 74%, compared to Paint B as it is. When unconventional fillers replace the siliceous one, μ is 23% (Bresin-F1) and 25% (Bresin-F2) lower than in Paint B as it is.

Table 3. Results from observation of molds growth

Week	Blank				Paint A				Paint B				Paint B-F1				Paint B-F2			
	A [1]		P [2]		A [1]		P [2]		A [1]		P [2]		A [1]		P [2]		A [1]		P [2]	
	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2
1	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	++	++	++	++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	++	++	++	++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[1] Aspergillus niger (A); [2] Penicillium chrysogenum (P).

On the real support, the addition of F1 implies a 46% reduction of μ, whereas the addition of F2 a 52% reduction of μ compared to Paint B as it is. The reduction of μ is confirmed also when fillers fully replace the conventional ones with μ 23% (Bresin-F1) and 25% (Bresin-F2) lower compared to Paint B as it is.

Literature shows that the addition of highly porous nano-fillers, such as nano-silica gel in coatings, does not worsen the water vapor permeability of the real support [33]: this result is reached also in the current experimentation even if micro-sized fillers are used. Better performance is observed in case of filler addition by the formation of a more porous structure as the binder content decreases. Indeed, literature has already been shown that the barrier property against humidity of a waterborne acrylic-based paint film decreases with decreased binder content [61].

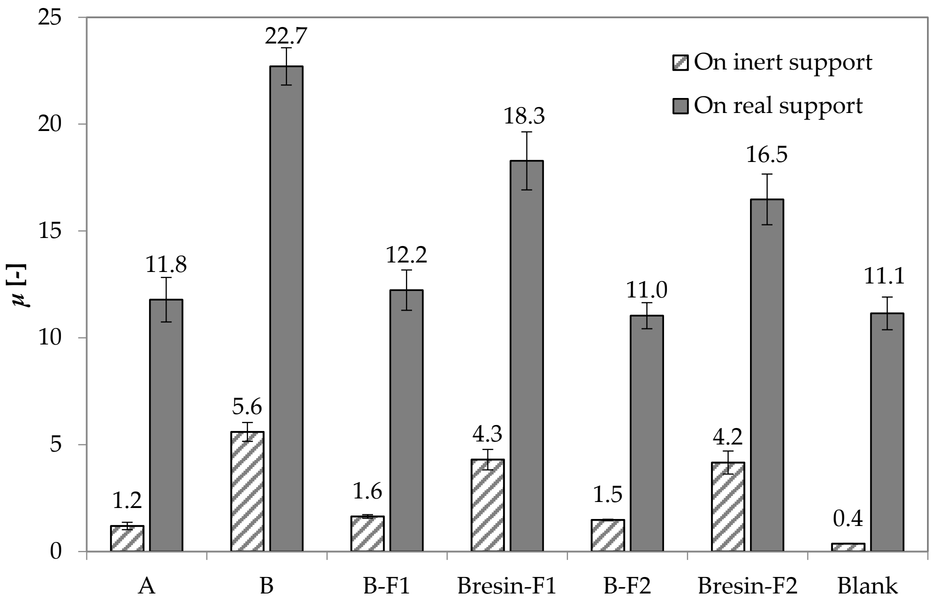

Figure 4. Water vapor diffusion resistance factor μ of paints applied on the real support or inert support. Blank is the support (real or inert) without coating.

3.3. Moisture Buffering Capacity

Figure 5 shows results of MBC in terms of *MBV*; Figure 6 shows the uptake/release of water vapor during the cycles by the two different substrates: it is evident that the inert substrate, a PVC sheet in this case, has as a negligible mass change [55].

On the inert substrate, Paint A gives a slightly higher *MBV* than Paint B. The addition of fillers improves the MBC of Paint B: the addition of F1 implies a *MBV* three times higher compared to that of the same paint without addition, the addition of F2 implies a *MBV* 20% higher compared to that of the same paint without addition. The total replacing of conventional fillers with highly porous ones still increases the *MBV*, even if at a lower level.

Being a porous mortar, the real support guarantees the penetration of water vapor. The application of Paint A on the real support does not change the breathability of the support. When Paint B is applied, an 18% decrease of *MBV* is detected. Again, the addition of fillers enhances the performance of Paint B. The addition of F1 implies a 29% increase of the *MBV* value, whereas the addition of F2 implies a 19% increase of the *MBV* value, compared to Paint B as it is.

When unconventional fillers replace the siliceous filler in volume, a better performance is still recorded even if at a lower level. In this case, only with F1 (Bresin-F1) the *MBV* becomes 17% higher, whereas with F2 (Bresin-F2) the improvement is not significant.

Performance of Paint B becomes comparable with that of Paint A with the addition of fillers. Since porous mortar substrates are the real active material in terms of MBC, the addition of paints should guarantee the same transport of water vapor, without any restriction [62], as Paint A acts. The unconventional fillers increase the porosity and specific surface of the paints allowing moisture to penetrate through these materials and to reach the underlying mortar layer [41] able to uptake and release water vapor [63]. This property is more evident when the unconventional fillers are added because, in this case, the higher total presence of fillers (conventional and unconventional), and obviously the lower quantity of binder, increases the overall porosity of the paint more than when unconventional fillers replace the siliceous ones [55].

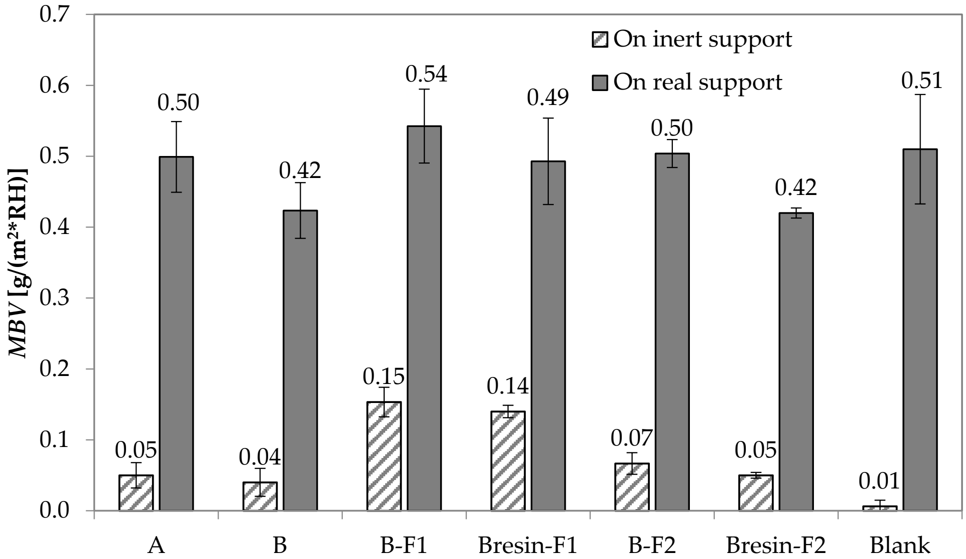

Figure 5. Moisture buffering value (*MBV*) of paints applied on the real support or inert support. Blank is the support (real or inert) without coating.

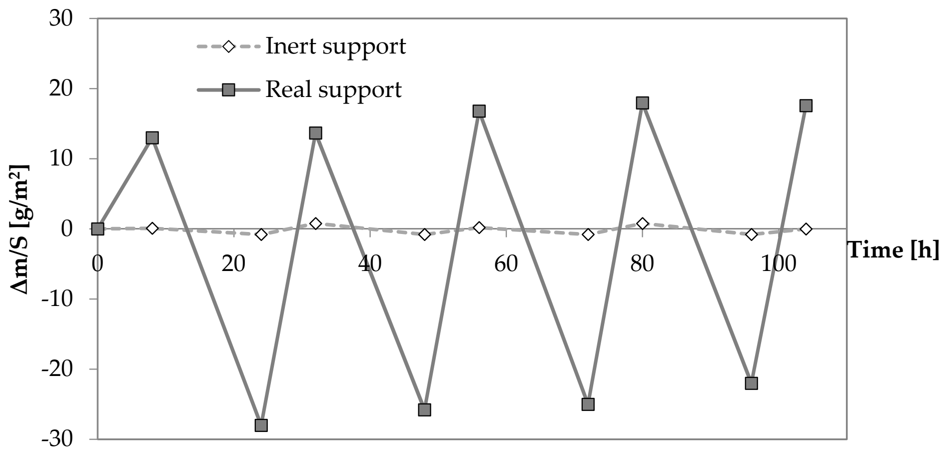

Figure 6. Change in water vapor content Δm of real (mortar) and the inert support normalized on the exposed surface S.

3.4. Depolluting Capacity

Figure 7 shows the trend line of the MEK residual concentration inside the box with different specimens as a function of exposure time. MEK needs at least 10 min to be completely vaporized and homogenized in the sealed box, hence data are considered consistent only after this time. Figure 8 compares the MEK residual concentrations in the box after 120 min of testing. When liquid MEK is injected inside the empty box, the concentration increases instantaneously in the first few minutes. Then, due to further evaporation of liquid MEK and homogenization of the air inside the hermetic box, the concentration increases sensibly for about further 20 min. The concentration remains constant for the rest of the monitored period (t = 120 min). This trend is shown by the empty trend line. When specimen is tested there is a decrease in concentration. This phenomena is already reported in [47]. However, both Paints A and B do not show relevant depolluting capacity. The detected MEK concentration inside the box remains quite constant in time and the obtained values are comparable to those already reported in the literature with the same test method for non-adsorptive materials [47].

The use of unconventional fillers increases the depolluting properties of Paint B. The addition or the replacement of the siliceous filler with F2 implies 15% and 12% higher adsorbing capacity compared to Paint B as it is, respectively. The best performance is obtained with F1: the addition or the replacement of the siliceous filler with F1 implies 20% and 16% higher adsorbing capacity compared to Paint B as it is, respectively.

The use of high specific surface and porous fillers can improve the depollution ability in terms of adsorptive capacity of acrylic paints for indoor applications.

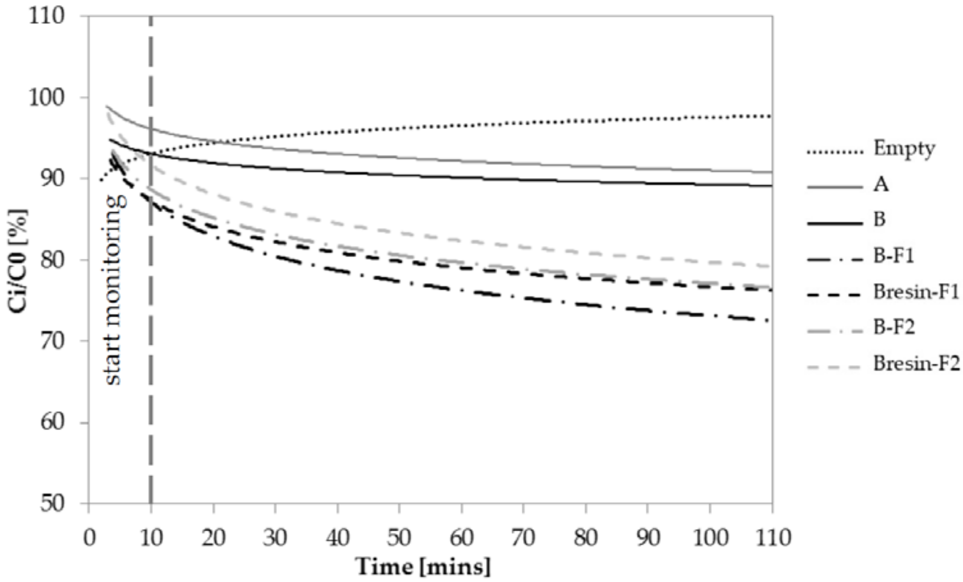

Figure 7. Methyl-ethyl-ketone (MEK) residual concentration Ci/C0 inside the box as a function of exposure time when paints are applied on the inert support.

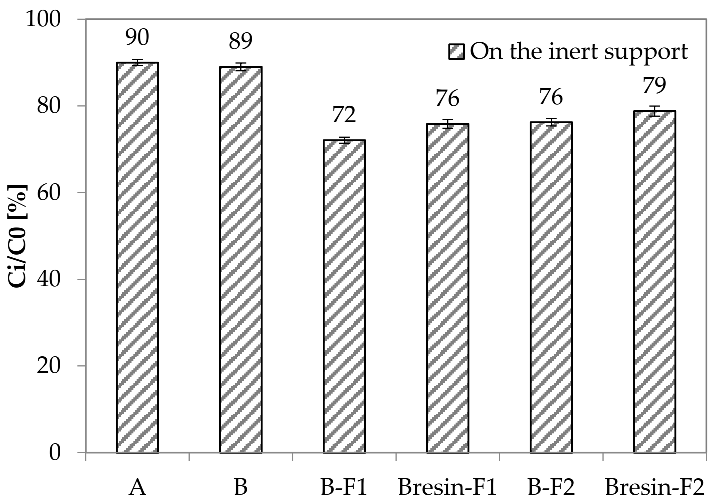

Figure 8. Depollution capacity in terms of MEK residual concentration Ci/C0 inside the box after 120 min.

4. Conclusions

In this paper, the properties of two different commercial acrylic paints, Paint A for indoor applications and Paint B for indoor/outdoor applications, have been compared. In Paint B, the effect of using unconventional adsorbent fillers F1 and F2 in the formulation, both as addition or as a total replacement of the conventional siliceous filler volume, was also tested on the ability of the paint to passively improve IAQ.

The obtained results show that:

- The use of unconventional fillers, especially F1, slightly reduces the fluidity of the paint only if added in the formulation. However, this fact does not affect the applicability of the paint.
- The use of unconventional fillers, both as addition or as total replacement of the siliceous filler, does not affect the ability of paint to inhibit the growth of molds.
- Paint A is more breathable than Paint B. The application of Paint A on the mortar substrate does not substantially change the substrate breathability. The application of Paint B halves the breathability of the substrate. However, the use of unconventional fillers counteracts this decrease up to 75%, if added, and up to 25% as a substitute for the original filler, especially when F1 is used.
- Paint A has a slightly higher moisture buffering capacity than Paint B. The application of Paint A on the mortar substrate does not substantially change the substrate moisture buffering capacity. The application of Paint B decreases the moisture buffering capacity of 18%. However, the use of unconventional fillers counteracts this decrease up to 29%, if added, and up to 17% as a substitute of the original filler, especially when F1 is used.
- Paint A and Paint B do not have depolluting properties in terms of VOCs adsorption capacity. However, Paint B becomes adsorbent when unconventional adsorbent fillers are used. Under the current test conditions, the fillers F1 and F2 give 20% and 16% higher adsorption capacity to Paint B, respectively, when they are added to Paint B as it is.

Therefore, even if Paint B negatively modifies the beneficial properties of the mortar substrate concerning IAQ, the use of highly porous fillers, especially the addition of F1 to the formulation, allows the recovery of the same properties of the substrate or even their improvement.

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