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S.S. PREVENZIONE E DIAGNOSI DANNI DA FUMO

# Comparison between particulate matter mass, number of particles, ultrafine particle and black carbon emissions by electronic and normal cigarettes in real-life conditions

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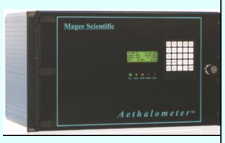
**Aims:** An electronic cigarette is a battery-powered device that produces an aerosol containing a mixture of nicotine, propylene glycol and flavoring, depending on the different commercial brands. E-cigarettes pose a regulatory challenge to the medical community, as they may reduce the harm of cigarette smoke but at the same time reinforce addictive smoking behavior. Uncertainties also exist as to whether they do promote a clinically relevant cessation rate in smokers who use e-cigarettes to quit smoking. Furthermore, e-cigarettes are supposed to emit much fewer pollutants in both particulate matter (PM), fine particles (FP), ultrafine particles (UFP) and black carbon(BC). The aim of the present study was to investigate the emission of PM generated by e-cigarettes and normal cigarettes under real-life conditions.

Different models of e-cigarettes

**Methods:** Real-time measurement and comparison of electronic cigarettes (Elips Serie C, with and without nicotine 16 mg, Ovale Europe Srl) with and without nicotine and normal cigarettes in a 48 $m^3$ normal office of an Italian comprehensive cancer Institute with no air conditioning and 0.8 air exchange rate (ACH) of PM mass using pre-calibrated model Aerocet 531 of Metone Instruments Inc. as $PM_1$, $PM_{2.5}$, $PM_7$, $PM_{10}$ and TSP in µg/$m^3$, FP number of particles on 8 sizes from 0.3 to 10.0 µm using model 212-2 of Metone Instruments Inc., UFP in number of particles per cubic centimeter from 10 to 1,000 nanometers using model TSI3007 of TSI and BC using model AE31 of Magee Scientific Inc.. Vapour phase nicotine was measured using passive filters and GC analysis. Outdoor concentrations were measured contemporaneously to compensate for urban background changes and all data are expressed in difference over the background.

Model TSI 3007

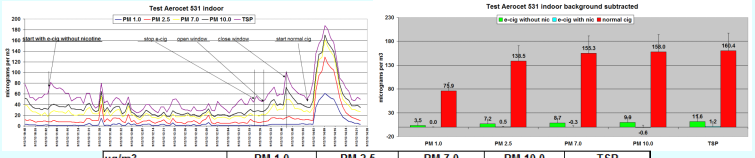


Model AE31

Model 212-2

Nicotine sodium bisulphate passive samplers

**Results:**



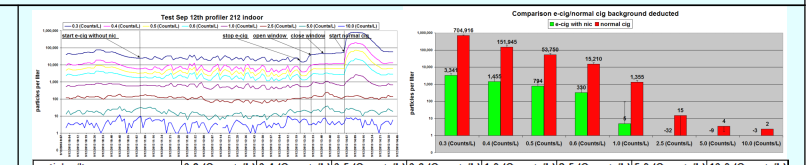

| ug/m3 | PM 1.0 | PM 2.5 | PM 7.0 | PM 10.0 | TSP |
|---|---|---|---|---|---|
| e-cig without nic | 3.5(7.3) | 7.2(9.6) | 8.7(9.9) | 9.9(10.3) | 11.6(15.5) |
| e-cig with nic | 0.0(0.3) | 0.5(1.1) | 0.3(3.1) | 0.6(4.4) | 1.2(10.1) |
| normal cig | 75.9(18.0) | 138.5(32.5) | 155.3(36.2) | 158.0(36.5) | 160.4(37.1) |

Negative numbers in red. Measurements of very small negative values in concentrations may be due to the instrument intrinsic noise level. Test t of Student e-cig without nic with normal cig p = < 0.0001

| Increase factor of normal cigs | PM 1.0 | PM 2.5 | PM 7.0 | PM 10.0 | TSP |
|---|---|---|---|---|---|
| with e-cig without nic | 22.0 | 19.3 | 17.9 | 15.9 | 13.9 |
| with e-cig with nic | 75.9 | 295.9 | 155.3 | 158.0 | 133.6 |

Emission factor in µg/min of e-cig not applicable. For normal cigarettes results as table below:

| ug/min normal cig | PM 1.0 | PM 2.5 | PM 7.0 | PM 10.0 | TSP |
|---|---|---|---|---|---|
| Emission factor | 5,028 | 10,063 | 11,443 | 11,627 | 11,903 |



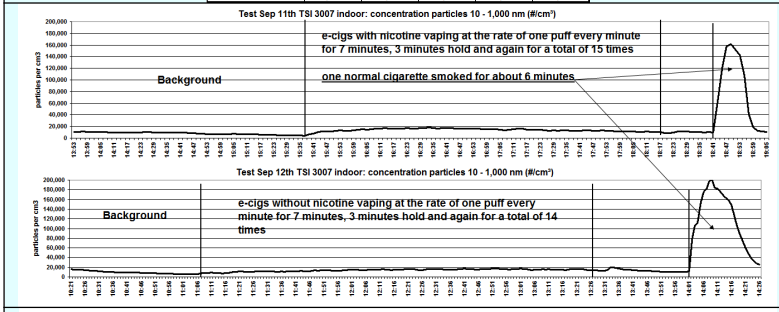

| particles/lt | 0.3 (Counts/L) | 0.4 (Counts/L) | 0.5 (Counts/L) | 0.6 (Counts/L) | 1.0 (Counts/L) | 2.5 (Counts/L) | 5.0 (Counts/L) | 10.0 (Counts/L) |
|---|---|---|---|---|---|---|---|---|
| e-cig without nic | 3,341(855) | 1,455(1,125) | 794(752) | 330(390) | 5,0(89) | 32(10) | 9,0(2) | 3(0) |
| normal cig | 704,916(69,290) | 151,945(26,783) | 53,750(10,661) | 15,210(3,520) | 1,355(347) | 15(28) | 4(2) | 2(0) |

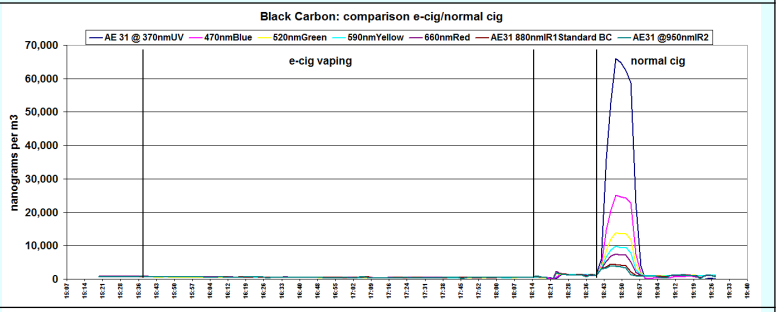
Negative numbers in red. Test t of Student e-cig without nic with normal cig p = < 0.0001

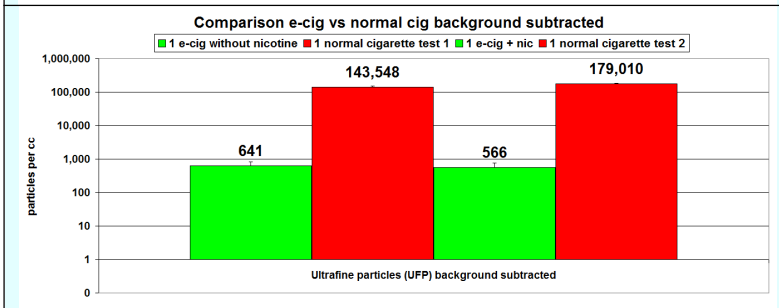
| Increase factor of normal cigs | > 0.3 | > 0.4 | > 0.5 | > 0.6 | >1.0 | > 2.5 | > 5 | >10.0 |
|---|---|---|---|---|---|---|---|---|
| with e-cig without nic | 210.96 | 104.41 | 67.69 | 46.11 | 265.16 | -0.47 | -0.39 | -0.87 |
| with e-cig with nic | 382.82 | 82.52 | 29.19 | 8.26 | 0.74 | 0.01 | 0.00 | 0.00 |

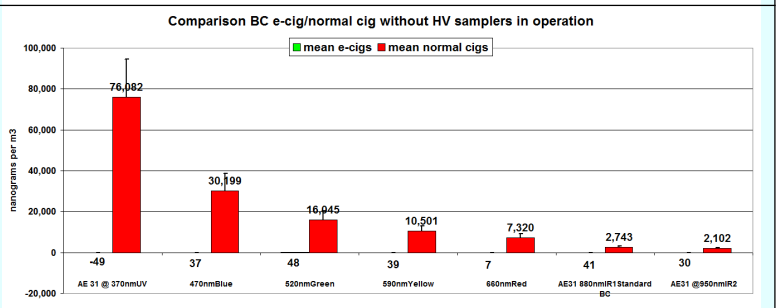
Emission factor in µg/min of e-cig not applicable. For normal cigarettes results as table below:

| ug/min normal cig | > 0.3 | > 0.4 | > 0.5 | > 0.6 | >1.0 | > 2.5 | > 5 | >10.0 |
|---|---|---|---|---|---|---|---|---|
| Emission factor | 7,184,851 | 1,727,516 | 652,294 | 203,826 | 23,449 | 1,365 | 199 | 69 |




| particles per cm3(SD) | 1 e-cig without nicotine | 1 normal cigarette test 1 | 1 e-cig + nic | 1 normal cigarette test 2 |
|---|---|---|---|---|
| Ultrafine particles (UFP) | 641(185) | 143,548(8,150) | 566(190) | 179,010(913) |

| | 1 e-cig without nicotine | 1 e-cig + nic |
|---|---|---|
| Increase factor of normal cig | 224.1 | 316.5 |

| Emission factors | particles/min |
|---|---|
| e-cig without nic | 21,496 |
| e-cig with nic | 32,448 |
| normal cig 1 | 1,639,521 |
| normal cig 2 | 2,055,456 |

- Test t of Student e-cig with and without nic with normal cig p = < 0.0001
-Test t of Student between e-cig with and without nic p = < 0.0001

| nanograms/m3 | AE 31 @ 370nmUV | 470nmBlue | 520nmGreen | 590nmYellow | 660nmRed | AE31 880nmIR1Standard BC | AE31 @950nmIR2 |
|---|---|---|---|---|---|---|---|
| mean e-cigs | 49(138) | 37(178) | 48(139) | 39(172 | 7(224) | 41(241) | 30(245) |
| mean normal cig | 76,082(18,542) | 30,199(8,562) | 16,045(4,348) | 10,501(2,626) | 7,320(1,744) | 2,743(459) | 2,102(372) |

- Negative numbers in red. Measurements of very small negative values in concentrations may be due to the instrument intrinsic noise level.
- Test t of Student e-cig with and without nic with normal cig p = < 0.0001
**NOTE: Black Carbon concentrations during vaping of e-cig do not increase above intrinsic noise level of the analyzer and therefore it is possible to conclude that e-cig do not emit Black Carbon.**

**NICOTINE THREE TESTS:** e-cigs below detection limit of 0.02 µg/m. Normal cigarettes showed concentrations of: 16.54, 26.04 and 16.41 µg/$m^3$.

**Conclusion:** our investigation proved that e-cigarettes produce much less PM than conventional cigarettes and no black carbon and therefore may be less hazardous for smokers and also in terms of secondhand exposure. This finding can be of interest to physicians and policy makers, but further studies are necessary to investigate acute and chronic effects of secondhand exposure to e-cigarette smoke in order to rule out any possible issues of health concern.