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S.S. **PREVENZIONE E DIAGNOSI DANNI DA FUMO**

18th ETH Conference on Combustion Generated Nanoparticles

Comparison between particulate matter mass, number of particles, ultrafine particle and black carbon emissions by electronic and normal cigarettes in real-life conditions
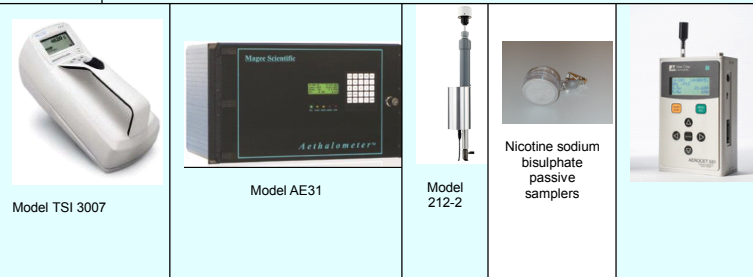
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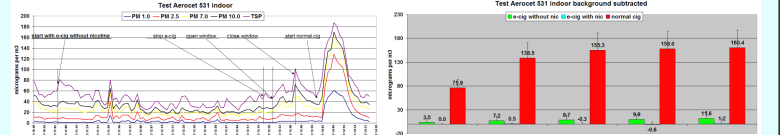
Aims: An electronic cigarette is a battery-powered device that produces an aerosol containing a mixture of nicotine, propylene glycol and flavoring, depending on the different commercial brands. E-cigarettes pose a regulatory challenge to the medical community, as they may reduce the harm of cigarette 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 $\mu g/m^3$, 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.
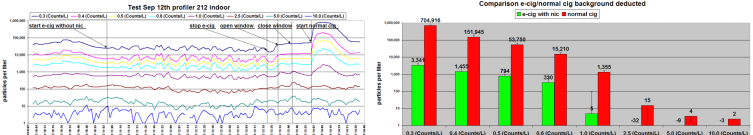
Model TSI 3007   Model AE31   Model 212-2   Nicotine sodium bisulphate passive samplers

Results:

Test Aerocet 531 indoor / Test Aerocet 531 indoor background subtracted

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

Test Sep 12th profiler 212 indoor / Comparison e-cig/normal cig background deducted

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)

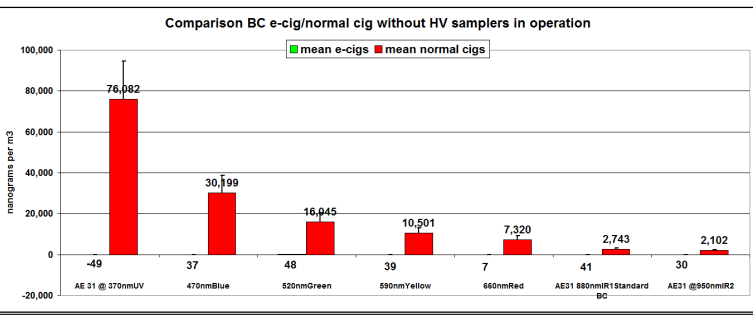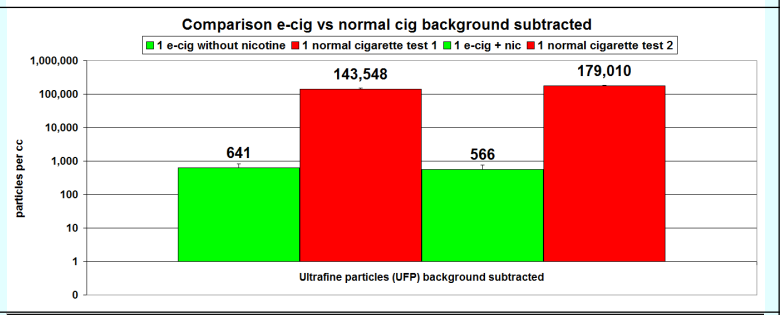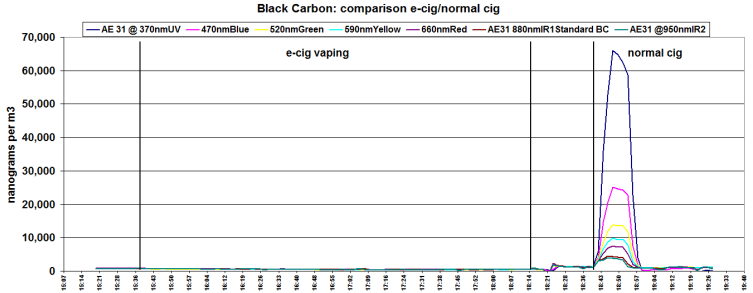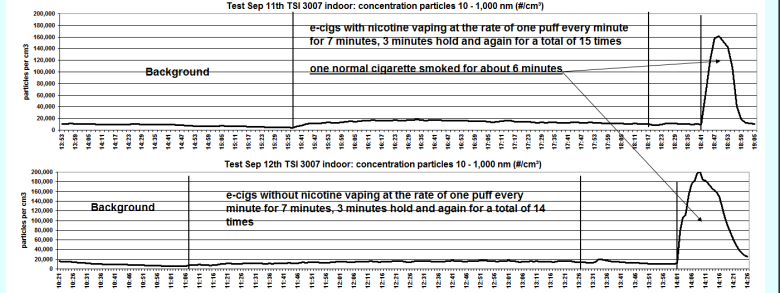Negative numbers in red. Test t of Student e-cig without nic with normal cig p = < 0.0001

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

Test Sep 11th TSI 3007 indoor: concentration particles 10 - 1,000 nm (#/cm³)
e-cig with nicotine vaping at the rate of one puff every minute for 7 minutes, 3 minutes hold and again for a total of 15 times
one normal cigarette smoked for about 6 minutes

Test Sep 12th TSI 3007 indoor: concentration particles 10 - 1,000 nm (#/cm³)
e-cigs without nicotine vaping at the rate of one puff every minute for 7 minutes, 3 minutes hold and again for a total of 14 times

Black Carbon: comparison e-cig/normal cig
e-cig vaping / normal cig

Comparison e-cig vs normal cig background subtracted
1 e-cig without nicotine: 641; 1 normal cigarette test 1: 143,548; 1 e-cig + nic: 566; 1 normal cigarette test 2: 179,010
Ultrafine particles (UFP) background subtracted

Comparison BC e-cig/normal cig without HV samplers in operation
mean e-cigs / mean normal cigs

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)

Increase factor of normal cig	1 e-cig without nicotine	1 e-cig + nic
	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 cigs	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/m³.

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.