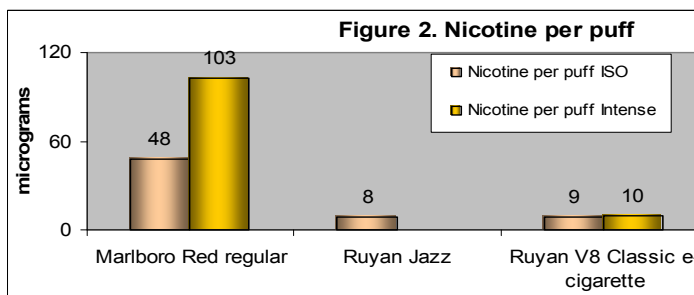
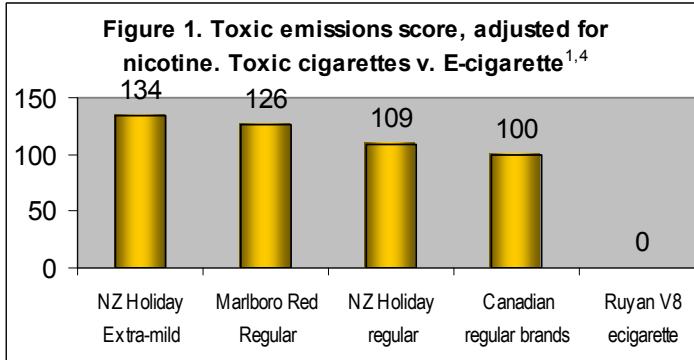


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## Ruyan® E-cigarette Bench-top tests

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Health

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**Background** Electronic cigarettes, without tobacco, flame or smoke, claim to be cigarette substitutes and to deliver nicotine safely, without smoke toxicants. Are these claims justified?

**Aim** To assess the Ruyan® e-cigarette and its mist for safety, emissions, and nicotine dose.



### Participating laboratories, methods, materials

- 1) Environmental Science and Research, Porirua NZ. *Cartridge liquid*: Monoamine oxidase inhibition (Kynur-amine substrate method); Nicotine (GCMS); Heavy metals (by ICP-MS)
- 2) Hill Laboratories, NZ. *Mist*: GCMS, Type II ATD, qualitative. 3) Hort Research, NZ. *Liquid* for 34 PAHs, by GCMS. 4) Labstat International ULC, Canada. *Liquid*: TSNAs, by LC-MS/MS. *Mist*: 14 PAHs and azarenes, Vinyl Chloride, acetamide, 7 volatile TSNAs. 5) Lincoln University, NZ. *Liquid*: HS-SPME & GCMS, qualitative. 6) National Radiation Lab. NZ For Pb210 gamma emitting nucleotides.
- 7) Syft Ltd NZ *Mist, Liquid* VOCs SIFT-MS
- 8) Duke University CNSCR Bioanalytical Lab. USA. *Mist*: Nicotine by GC MS.
- 9) British American Tobacco, Group R&D, (UK) *Liquid, mist*: Chemistry, smoke tests by ISO method. Nicotine in puffs, particle size (TSI 3090 MN USA), pressure drop.<sup>1</sup>

**Test materials** Ruyan in Beijing supplied V8 Classic e-cigarettes and 16 mg nicotine-labeled cartridges ex-factory to test laboratories, directly, or via distributors. Most were manufactured in 2008 and tested in 2008-9. Batteries were re-charged before testing, and fresh cartridges used. Shelf life at time of testing varied. An ISO machine smoked 1 mg tar cigarette provided smoke toxicants.<sup>1</sup>

**Selection of toxicants for testing of e-cigarette mist.** Selection was based on published priority lists of cigarette smoke toxicants: 9 recommended by WHO TobReg committee for mandatory lowering;<sup>5</sup> 37 prioritised by toxicological risk assessment by Fowles & Dybing<sup>6</sup> additional to the above 9; 13 additional to the above 46, priority tested on brands sold by British Columbia,<sup>7</sup> known loosely as the Hoffman analytes.

**Not tested:** acetaldehydes (delayed, due to world shortage of reagent); hydrazine, chlorinated dioxans, oxides of nitrogen, and urethane.

## Results

**Toxicology and safety** In Ruyan V8 e-cigarette mist tested for over 50 priority-listed cigarette smoke toxicants so far, no such toxicant was found. A possible exception was mercury, detected in trace quantity of 0.17 ng per e-cigarette. However, this was barely above the reporting limit of 0.13 ng, and within the reported 38% coefficient of variation.

**Chemistry** The cartridge (labeled 16 mg), contained 13 mg<sup>1</sup> to 14 mg<sup>3</sup> nicotine and 1.1g propylene glycol (PG), and yielded >300 35 mL puffs of mist: 82% PG, 15% water, 1% free-based nicotine, 2% particulates and flavours.<sup>1</sup> Vaporisation occurred at 54°C, powered by 0.1 mW per puff from lithium-ion battery.<sup>1</sup> Pressure drop was 152 mmWG, compared with 80-120 mmWG for a tobacco cigarette.<sup>1</sup> Particle size 0.04 micron (count median diameter), was about one-fifth of that for tobacco smoke.<sup>1</sup>

**Nicotine delivery per puff** A 35 mL puff from the Ruyan® V8 delivers only 10% of the nicotine obtained from a similar puff of a Marlboro regular cigarette. Deeper 50 mL puffs from the Ruyan V8 delivers only slightly more nicotine.

**Site of nicotine absorption** No deposition of aerosol nicotine occurred on pulling mist through a cascade impactor.<sup>2</sup>

## Discussion

**Main finding.** Testing for over 50 cigarette key smoke toxicants found none in any but trace quantity, in Ruyan V8 mist.

**Safety of e-cigarettes as a product class** Safety results refer to the Ruyan® V8 Classic. However the low operating temperature (54°C) of the atomiser - 5 to 10% of the temperature of a burning cigarette - suggests e-cigarettes as a class are unlikely to emit cigarette toxicants in their mist.

**Nicotine dose** (Figure 2) An e-cigarette user will need to take more puffs more often, and deeper puffs confer no advantage for V8 users. Six puffs every 5 minutes would deliver the same dose of nicotine delivered by shallow inhaling (10 puffs of 35 mL per puff) from one tobacco cigarette every hour, but would not achieve the high immediate nicotine boost which many smokers crave. Nicotine overdose is unlikely, even though nicotine delivery may vary between brands.

**Nicotine absorption site** The nicotine dose and particle size are too small to ensure deposition in the alveoli or bronchioles and rapid nicotine absorption as in cigarette smoking.

**Limitations of study** The results apply only for the products tested. Extrapolation to all product sold assumes production only from internationally-certified good manufacturing sites, and trademark enforcement.

## Conclusion

Ruyan® V8 nicotine e-cigarette users do not inhale smoke or smoke toxicants. The modest reductions recommended in 2008 by WHO's Tobacco Regulation committee for 9 major toxicants in cigarette smoke, in line with Articles 9 and 10 of the FCTC (WHO Framework Convention Tobacco Control treaty), are already far exceeded by the Ruyan® e-cigarette, as it is free of all accompanying smoke toxicants. Absolute safety does not exist for any drug, but relative to lethal tobacco smoke emissions, Ruyan e-cigarette emissions appear to be several magnitudes safer. E-cigarettes are akin to a medicinal nicotine inhalator in safety, dose, and addiction potential.

E-cigarettes are cigarette substitutes. If they can take nicotine market share from cigarettes, and that is the big question, they will improve smoker and population health. They may also have a secondary role as medicinal nicotine inhaler quitting aids. Further trials of acceptability, addiction potential, clinical safety, and quitting efficacy are needed.

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**Competing interests** None. Neither the author, or his company, has any financial interest in Ruyan or any other manufacturer.

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