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Jack London and White Fang: a lost struggle

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Abstract. The California State Parks curators granted access to artifacts owned by Jack London that are in storage in their Sonoma Barracks in Sonoma, CA. A medicine case, drug vials, and various paper documents that covered the period of his life from 1906 to 1915 were examined for drug residues left on their surface. All the objects were tested with the non-invasive surface analysis EVA (ethylene-vinyl acetate) technology, which consist of a foil studded with ground mixed-bed cation/anion exchangers as well as with C_8 and C_{18} resins. The harvested material collected by the foils was analysed via GC-MS and the following 12 drugs were identified: *N*-(4-ethoxyphenyl) acetamide, phenyl salicylic acid, morphine, 6-monoacetylmorphine, 3-acetylmorphine, diacetylmorphine, dipenteneglycol, quinine dihydrochloride, quinine base, atropine, scopolamine and hyoscyamine. Despite the claims by his biographers that he used opium, morphine, and heroin on a regular basis this assertion could not be confirmed by the chemical analyses of the objects here tested. Only two opioids were discovered, morphine and diacetylmorphine (heroin) both of which could have been derived from the use of common, legal (over-the-counter) flu and cough medications.

Keywords. Jack London death, Morphine, Scopolamine, Hyoscyamine, Atropine, Quinine, Diacetylmorphine.

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1. Introduction

Jack London, the famous American novelist, journalist, and social activist, author, among others, of the novels *The Call of the Wild* and *White Fang*, did not have an easy life. The first problems occurred already in 1897 when London (aged 21) and his sister's husband captain Shepard sailed to join the Klondike Gold Rush. This was the setting for some of his first successful stories. London's time in the rough Klondike, however, was detrimental to his health. Just like so many other adventurers who were malnourished in the goldfields, London developed scurvy. His gums became swollen, resulting in the loss of his four front teeth. A constant excruciating pain affected his hip and leg muscles, and his face was ploughed with marks that always awoke memories of the struggles he faced in the Klondike. In 1904, when he was sent as a correspondent to cover the Russo-Japanese

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war, he was arrested three times in rapid succession and could only be released through the personal intervention of President Theodore Roosevelt. Were this not enough, in 1907, when he and his second wife Charmian took a cruise on the yacht *Snark* to Hawaii and the South Pacific, they were plagued by unspecified tropical infections and diseases, including yaws and malaria. It would appear that when misfortune haunts a person, it sticks to him like a clam to a rock. In 1905, London purchased a 4.0 km^2 ranch in Glen Ellen, Sonoma County, California, on the eastern slope of Sonoma Mountain. He stated: "Next to my wife, the ranch is the dearest thing in the world to me". Very dear it was, no doubt: London spent $80,000 to build a 1400 m^2 stone mansion called Wolf House on the property. However, just as the mansion was nearing completion, two weeks before he would move in, it was destroyed by fire [1].

Between 1908 and 1916 (the year of his death) London had settled down and lived on the ranch in his Glen Ellen estate, leaving it about six months each year for travel to Hawaii and visits to foreign countries. He died of kidney failure on the ranch on November 22, 1916. The death certificate was signed by Jack London's personal physician, William S. Porter, MD, who three years earlier had operated on him for appendicitis and made the diagnosis of nephritis. Porter signed the cause of death on the death certificate as "uraemia following renal colic (kidney stones)" with the contributing factor as "Chronic Interstitial Nephritis" [2].

The rumours that the world-famous author had died instead from an accidental or intentional morphine overdose began within days of his death. The question of how he died has been analysed and debated to this day. The goal in this research was to survey a few selected items, known to be owned by Jack London, in order to identify potential drugs that he may have left from the handling of these objects. A wide range of drugs including the opioids and their metabolites are now capable of being measured in sweat and saliva left by fingerprints on the objects [3].

Permission was received to explore selected objects belonging to Jack London via our EVA methodology, a technique that has provided unique results in exploring many items of the world Cultural Heritage [4,5], including morphine found on the handwritten manuscript of the Russian novelist Mikhail Afanasyevich Bulgakov [6]. This technology has also been certified not to damage or contaminate these precious relics [7,8]. The results obtained on Jack London's personal belongings are illustrated below.

Table 1. The nine objects tested with the EVA technology

A&F medical case	Object date
A&F sole leather medicine case	1911–1916
Vial of cholera tablets	1911–1916
Am. J. Clin. Med. article	September 1911
Rattlesnake bite booklet	ca 1906
Misc. items	**Object date**
Taylor thermometer certificate	March 1906
Taylor thermometer storage case	March 1906
Vial of Chlorodyne liquid	July 1908
Vial of Formamint tablets	1914
Wyeth vial of cholera tablets	November 22, 1915

2. Materials and methods

2.1. *Samples tested with the EVA films*

The following items were examined with the EVA technology (Table 1): an Abercrombie & Fitch (A&F) sole leather medicine case from about 1911. Objects found inside the medicine case and tested included a glass vial of opium tablets; an article torn from the September 1911 issue of the *American Journal of Clinical Medicine*; and a booklet on rattlesnake bites folded up inside the medicine case, published ca. 1906. Additional items tested found in museum boxes labeled as having come from the Jack London estate included a Taylor thermometer certificate dated March 1906 along with the thermometer case; a vial of Chlorodyne (a mixture of morphine in chloroform and ethanol) from 1908; a vial of Formamint lozenge tablets (composed of formaldehyde and sucrose) from about 1914 and a Wyeth vial of opium tablets dated November 22, 1915. Only the outside glass surface of the vials with the unopened metal screw caps were tested for residues from the sweat or saliva left by fingers that may have touched the objects.

2.2. *Chemicals and materials*

Methanol (LC-MS Ultra CHROMASOLV, >99.9%), 2-propanol (LC-MS Ultra CHROMASOLV, >99.9%),

acetic acid (eluent additive for LC-MS, >99.9), ammonium bicarbonate (AMBIC), formic acid, ammonium bicarbonate (AMBIC), trifluoroethanol (TFE) (>99%), ammonium hydroxide, and water (LC-MS Ultra CHROMASOLV, >99.9%) were purchased from Sigma-Aldrich (Milwaukee, USA). Microcon YM-5 and C_{18} Zip-tip pipette tips were from Millipore UK Limited. The ultrapure water was obtained through a Millipore Milli-Q system (Milford, USA). The mixed-bed cation (SCX)/anion (SAX) exchange resins AG501 and C_8 and C_{18} pearls were from Bio-Rad (Hercules, USA).

2.3. *Synthesis and characterization of the EVA film*

A special plastic-like film based on ethylene-vinyl acetate (EVA) as binder of ground AG 501 mixed-bed cation/anion exchange, C_8 and C_{18} resins (all from Bio Rad) was prepared. A mixture was made comprising 70% 1–10 μm size ground beads and 30% EVA (the melting temperature was 75 °C). The proportion of the various resins in the plastic film was: 35% strong cation, 35% strong anion exchangers, 15% C_8 and 15% C_{18} hydrophobic resins. The blend of melted EVA and Bio-Rad resins was poured in a "Brabender" mixer W30 and laminated via a "Brabender" extruder KE19 (both from Brabender GmbH, Duisburg, Germany) in the form of either a thin film or diskettes, having a thickness of 200 to 300 μm.

2.4. *EVA film application*

All items were in storage in the California Parks Service Barracks in Sonoma, CA. A total of 16 EVA samples were taken on 9 different objects. All films were immersed in 2.0 mL of doubly distilled water (18 MΩ) for 10 min. Excess water was removed from each film by touching the edges of the films with a circle of Whatman No. 1 filter paper. The EVA diskettes were then immediately placed on the object, covered with a piece of Parafilm M followed by a round glass weight (200 g). Incubation was for 60 min at room temperature. The films were removed from the objects and placed into a small clear acrylic vial with a screw cap. Each vial was labelled on the cap with a black magic marker and a label with the number was fixed to the bottom of the vial. All 9 museum objects investigated were photographed before application of the films and then with the films applied and before the addition of the Parafilm M and the glass weight. The EVA films were only handled with sterilized plastic tweezers. One 65 mm × 10 mm EVA film was cut into smaller pieces for use with objects as required. For elution of material harvested by the EVA diskettes we used a two-step procedure: 70% methanol in doubly distilled water and a 60 mM ammonium acetate solution. The first step was collection of dry residues after elution in 70% methanol. The second step was an additional elution in 60 mM ammonium acetate.

2.5. *GC-MS analysis*

The two separate eluates were finally used for derivatization at 80 °C for 5 min in a mixed solvent of propionic anhydride and pyridine (5:2). The dried residues were reconstituted in 45 μL of propionic anhydride and 20 μL of pyridine. All reagents were vortex-mixed, then heated for 5 min at 80 °C and dried in air stream at 60 °C. The dried powders were reconstituted in 40 μL of methanol. For sample analyses a volume of 1 μL of each solution was injected into the GC-MS instrument. Gas chromatography–time of flight mass spectrometry (GC-TOF/MS) was run in a HP 6890 series GC, Split-less injector; 6890 series MS selective detector (EI mode 70 eV HP). Column length 50 m; 5% phenyl methyl siloxane capillary column HP-5MS (id 0.25 mm). Morphine-d3 was used as internal standard. GC-MS was run with a linear temperature program from 30 °C to 280 °C. A fused-silica capillary column and helium as the carrier and makeup gas were used. The period of separation was ~16 min. MS parameters: electron impact ionization source temperature (EI, 70 eV) was set at 250 °C; scan range 40/630 m/z, with an extraction frequency of 30 kHz. The chromatograms were acquired in TIC (total ion current) mode. Mass spectral assignment was performed by matching with NIST MS Search 2.2. Libraries, implemented with the MoNa Fiehns Libraries.

3. Results

3.1. *The artifacts tested*

Table 1 lists the 9 items tested with the EVA technology along with their dates. We offer here some examples of these objects probed via EVA films. Figure 1

Figure 1. The A&F sole leather medicine case with two EVA discs applied to the lid.

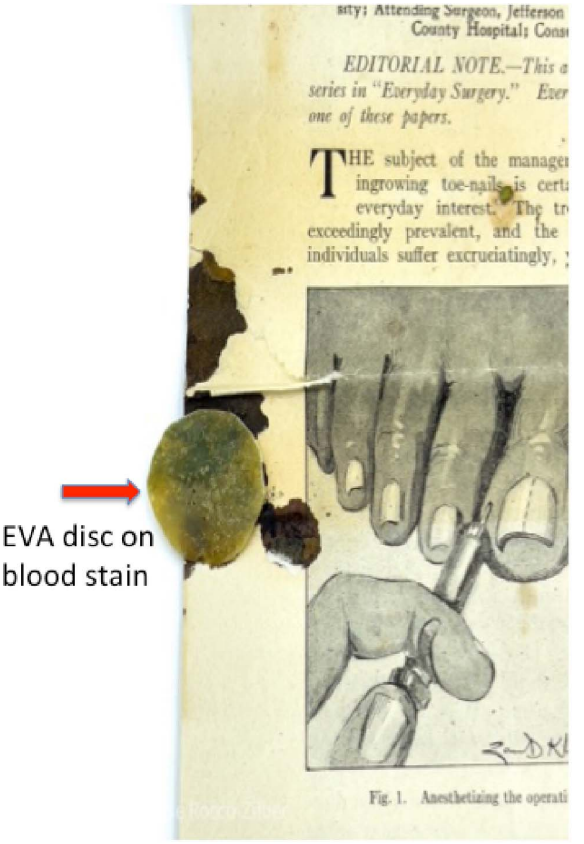

Figure 2. The article torn from the *American Journal of Clinical Medicine* dated September 1911. EVA diskette applied to a possible blood stain on the first page.

shows the A&F sole leather medicine case lid with two EVA diskettes applied. The left-hand cover of the case where fingers undo the snap; the lower right side of the typed instructions glued to the inside of the case; and an area on the outside of the leather case which appeared worn from holding the case in order to open the cover were all tested. Each diskette was covered with a piece of Parafilm M to prevent evaporation and then held down in place with a glass weight. A glass vial of opium tablets with a metal screw cap found in the A&F case was also tested. The 12-page booklet, *Rattlesnake Bite and How to Cure It* published about 1906 by Jack London's friend George Wharton James was found folded up inside the case [9]. Jack London wrote that he wanted this booklet to go with him on his four-horse trip to Oregon from June to September 1911 [10,11]. The cover of the booklet where fingers are used for opening was tested. Figure 2 shows the article by Breakstone on the surgical repair of ingrown toenails that was torn from the September 1911 issue of the *American Journal of Clinical Medicine* [12]. A possible dried blood stain on the left side of the first page was tested with an EVA film. Yoshimatsu Nakata, Jack London's valet from 1908 to August 1915 claimed that Jack London, "had no corns but suffered quite a good deal from ingrowing [*sic*] toenails" [13].

Additional items tested included a certificate of analysis for a Taylor thermometer dated March 30, 1906. Jack London wrote while he was in the Solomon Islands battling malaria among the crew of the *Snark* that "It was the first time I had used my medicine-chest thermometer, and I quickly discovered that it was worthless" [14]. Figure 3 shows the two EVA disks on the Taylor certificate before the Parafilm M and glass weights were applied. The Taylor thermometer case was also tested. A vial of Chlorodyne, which is morphine, dissolved in a mixture of ethanol and chloroform was tested. The vial label showed that it came from a pharmacy in Suva, Fiji where Jack Lon-

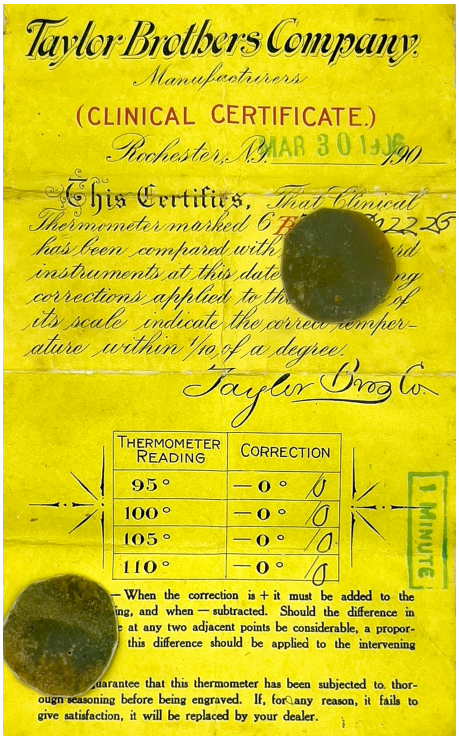

Figure 3. The Taylor thermometer certificate dated March 1906 with two EVA discs applied.

Figure 4. An empty vial of Formamint lozenges. The possible blood spot of the vial was tested with an EVA disc.

don and the crew of the *Snark* had arrived on their South Pacific voyage in May 1908 [15]. Figure 4 shows an empty vial of Formamint tablets. These are throat lozenges composed of formaldehyde and sucrose. A possible dried blood residue on the vial was tested. An ad for Formamint tablets in a San Francisco newspaper on February 8, 1914, included a testimonial from Jack London, "I am tremendously pleased with the antiseptic qualities of your Formamint Tablets. Formamint is a real cleaner of mouth germs" [16]. Finally, a bottle of opium tablets from Wyeth Pharmaceuticals provided by Bowman Pharmacy in Oakland, CA dated November 22, 1915 is shown in Figure 5. The left panel shows the applied EVA disc on its outside, whereas the right panel displays the same vial with the EVA disc wrapped up with Parafilm to prevent humidity loss during the 60 min application time. Letters from Bowman Pharmacy to Jack London in October 1915 informed him that they could not honour his request for additional opium tablets without a prescription [17]. They reminded him that this was due to the new Harrison Narcotics Act that began to be enforced in March 1915. This Federal law converted opium, morphine, codeine and heroin from over-the-counter drugs to prescription only. Jack London's daughter Joan London, his oldest child, recounted the difficulty that this caused her father in obtaining his requested tablets of opium [18].

3.2. *The drugs discovered*

Table 2 is a list of the 12 different drugs recovered from the probed items. No opioids were recovered from the leather of the A&F medicine case, or the surface of a glass vial of opium tablets found in the case. Eight of the nine items examined were also found to contain quinine base or quinine hydrochloride, and various combinations of the Belladonna constituent's atropine, hyoscyamine or scopolamine. Figure 7 displays the GC-MS profile of atropine and morphine (the other major peaks could not be identified exactly because the spectra were noisy) while Figures 8A and B give their respective MS spectra.

The drug N-(4-ethoxyphenyl) acetamide (Phenacetin) and phenyl salicylic acid (Salol) were

Figure 5. Wyeth vial of cholera (opium) tablets. Left side: EVA disk applied to the external surface. Right panel: vial wrapped up with Parafilm to prevent humidity loss.

Table 2. The twelve drugs found on the nine artifacts tested with the EVA technology

Drug	Molecular mass (Da)	Molecular formula
3-acetylmorphine (3-AM)	327.40	$C_{19}H_{21}NO_4$
6-acetylmorphine (6-AM)	327.40	$C_{19}H_{21}NO_4$
Acetophenetidin (Phenacetin)	179.22	$C_{10}H_{13}NO_2$
Atropine	289.40	$C_{17}H_{23}NO_3$
Diacetylmorphine (Heroin)	369.41	$C_{21}H_{23}NO_5$
Hyoscyamine	289.40	$C_{17}H_{23}NO_3$
Morphine	285.34	$C_{17}H_{19}NO_3$
Phenyl salicylic acid (Salol)	214.22	$C_{13}H_{10}O_3$
Quinine base	324.40	$C_{20}H_{24}N_2O_2$
Quinine dihydrochloride	397.30	$C_{20}H_{26}Cl_2N_2$
Scopolamine	303.35	$C_{17}H_{21}NO_4$
Terpin hydrate	170.25	$C_{10}H_{18}O_2$

found on 6 of the 9 objects. Phenacetin in the late 1940s was discovered to be converted in the body to acetaminophen, the actual active ingredient [19]. McNeill Laboratories (Johnson & Johnson) replaced Phenacetin with acetaminophen in 1955 and released it as Tylenol®. Salol was the trademark name for phenyl salicylic acid and sold as an alternative to acetyl salicylic acid, the chemical name for aspirin. Quinine was found on 7 of the 9 objects. Tablets of 300 mg or more were used for malaria. Jack and his wife Charmian along with Nakata returned from the *Snark* voyage in 1909 infected with malaria. Lower doses of quinine at 14 mg per tablet were added to a wide variety of combination drugs where it was

Figure 6. Vial of Squibb terpin hydrate and diacetylmorphine (heroin) cough suppressant tablets.

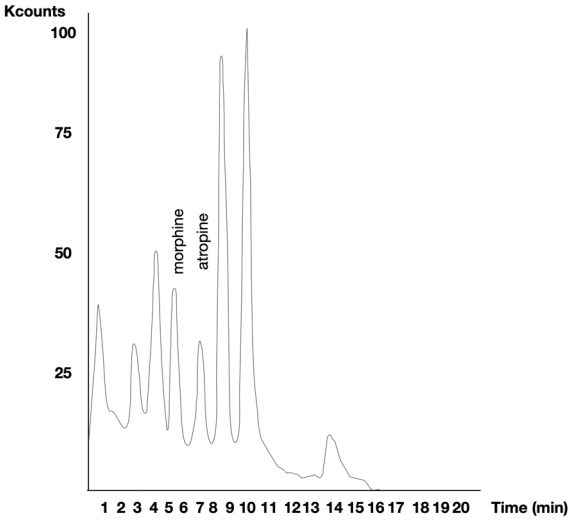

Figure 7. GC profiles of both morphine and atropine recovered from the objects tested.

believed to act as a mild antipyretic. Eight of the 9 objects contained one or up to three of the different components of Belladonna namely atropine (d,l-hyoscyamine), l-hyoscyamine, and/or scopolamine (hyoscine). Compound drugs often contained one or more of these drugs where they were used to dry up mucous membranes.

Seven of the nine objects had traces, on their surface, of diacetylmorphine (heroin) and terpin hydrate (Table 3). The three major metabolites of diacetylmorphine, 6-acetylmorphine (6-AM), 3-acetylmorphine (3-AM) and morphine were also recovered from 5 of the 7 objects that tested positive for diacetylmorphine and terpin hydrate (Table 3). The combination terpin hydrate-heroin was a common over-the-counter drug used to treat a wide range of respiratory disorders. Terpin hydrate was the expectorant and diacetylmorphine acted as the cough suppressant. This drug was used for coughs, colds and the flu. Diacetylmorphine was replaced with codeine in 1924 and terpin hydrate with guaifenesin in the 1990s. Today this combination drug of guaifenesin–codeine is sold as Robitussin AC® and is FDA approved for use in anyone over the age of 6 years. Six of the 9 objects contained surface residues from which morphine and atropine were also recovered.

It is noted that the 12 drugs discovered on the objects tested with the EVA technology could be accounted for by four vials of tablets found in Jack London's Squibb medicine case. This travel medicine case dates from 1909 and is the case on display in the Jack London Museum in Glen Ellen, CA. These drugs include Acetphenetidin [sic] and Salol, Squibb No. 11355-S-1 (acetophenetidin [Phenacetin] and phenyl salicylate); Rhinitis, Half Strength, Squibb No. 11300-S-1 (quinine and Belladonna); Terpin Hydrate & Heroin, Squibb No. 11500-S-1 (terpin hydrate & diacetylmorphine) (Figure 6). No vials of morphine-atropine were discovered in either the A&F or Squibb medicine cases. However, the Squibb case has a vial of Follicular Tonsillitis Squibb No. 10805-S-1 which contains a combination drug that includes morphine sulphate, atropine and salicylates.

4. Discussion

The use, abuse and potential addiction to the opioid drugs have become part of the biography and mythology of Jack London almost since the day he died in 1916. Biographies [20] and newspapers [21] have perpetuated the story of his chronic use (and abuse) of opium, morphine and heroin. The only opioids that were discovered in the residues left on the objects tested in this study were diacetylmorphine and its main metabolites morphine, 6-AM and 3-AM.

The absence of codeine (methylmorphine), a main metabolite of opium, helped rule out the presence of opium on the items probed. Diacetylmorphine (heroin) was only found when terpin hydrate was also present. This suggested that the source of the diacetylmorphine was the common (over-the-counter) cough medicine terpin hydrate-heroin

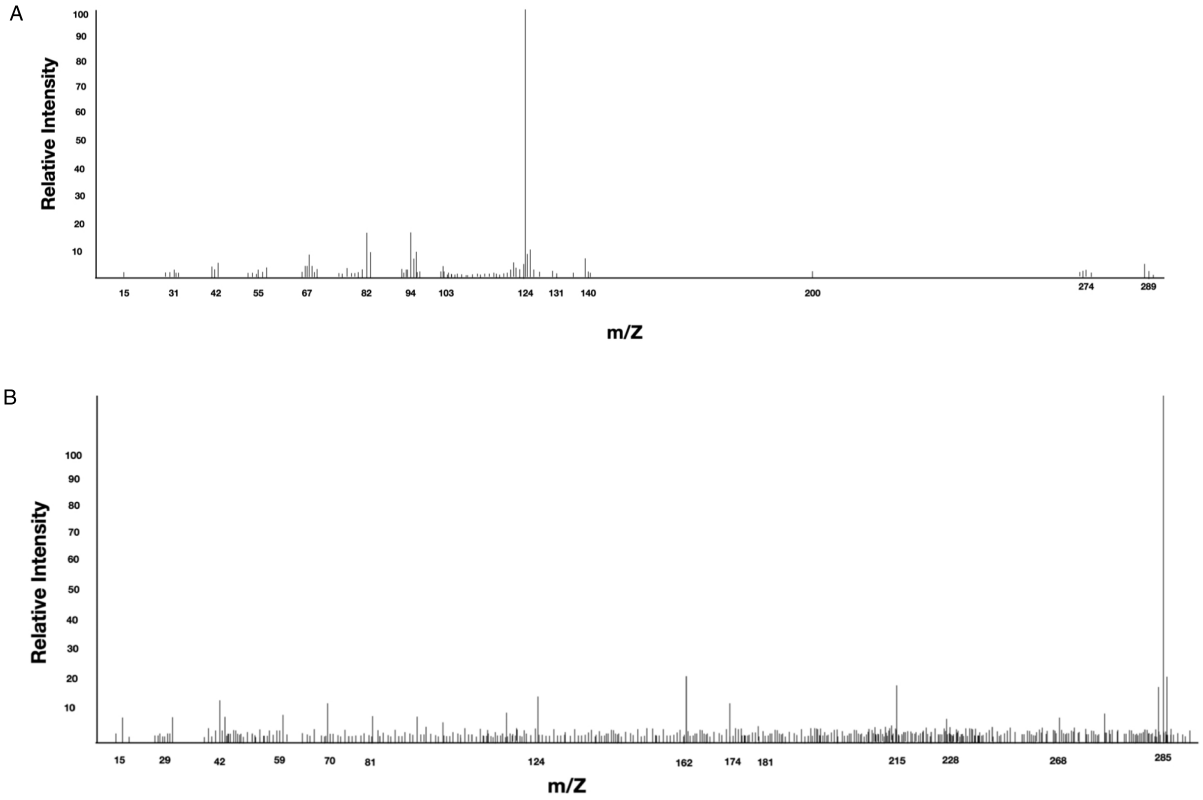

Figure 8. (A) MS spectrum of atropine. (B) MS profile of morphine, both drugs as recovered from the objects probed with EVA diskettes.

Table 3. The opioid drugs found on seven of the nine artifacts tested with the EVA technology

Object	Date	Heroin	Morphine	6-AM	3-AM
Taylor thermometer case	March 1906	Y	Y		
Rattlesnake bite Booklet	ca 1906	Y	Y		
Taylor thermometer certificate	March 1906	Y	Y	Y	Y
Chlorodyne vial	July 1908	Y	Y	Y	Y
Am. J. Med. surgical article	September 1911	Y	Y	Y	Y
Formamint tablet vial	1914	Y	Y	Y	Y
Wyeth vial of opium tablets	November 22, 1915	Y	Y	Y	Y

which evolved over the years into Robitussin AC and not from the direct ingestion or injection of heroin. Morphine and atropine were always found together. This could support the testimony of his two valets, Nakata and Sekine, who claimed that he used morphine on a regular basis [13]. Alternatively, morphine is a main metabolite of diacetylmorphine and atropine was added to a wide variety of over-the-counter flu and cold medications including the quinine–Belladonna combination that was consistently found on the objects tested.

5. Conclusions

Jack London's chronic use of the opioid drugs cannot be fully ruled out. However, the opioids found on

the nine objects tested would have most likely come from the usual over-the-counter cough and cold medications. The objects tested dated from about 1906 to 1915 and all the opioids detected were legal over-the-counter medicines until the enforcement of the Harrison Narcotics Act in March 1915. Jack London's death from an accidental or intentional morphine overdose might only be examined with objects that date from November 22, 1916, the day he died. In any event, our data exclude the hypothesis of suicide and of consumption of very large doses of drugs that might have been fatal to him. It is here noted how the EVA extraction technique is a formidable tool for subsequent chemical analyses of the objects probed.

Conflict of interest

The authors declare no competing financial interests.

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