

Abstract—A commercially available drug denaturing kit, the *Pill Terminator*, was determined to effectively denature approximately 43% of a sample of morphine on contact and approximately 55% within 48 h when used as directed by the package label. To obtain nearly 100% denaturation, simple stirring as described previously¹ can be undertaken.

Introduction

The disposal of excess or expired drugs, especially controlled substances, is a significant problem in the United States and other countries. In the U.S., the Drug Enforcement Agency (DEA) regulates the disposal of large quantities of unwanted controlled substances from a provider's inventory,² but these guidelines do not apply to consumers. Furthermore, pharmacists and physicians are not permitted by law to take back unused or expired prescription drugs on a routine basis due to potential liabilities. While the DEA has instituted events like "National Take Back Day" to encourage consumers to safely dispose of unwanted pharmaceuticals, anecdotal evidence suggests that many still tend to "flush" unwanted drugs down the toilet or discard them in the garbage. Neither of these methods of disposal is acceptable as they result in contamination of the environment. Because most sewage treatment plants are not equipped to separate them from wastewater, drugs that are disposed of in this way may ultimately compromise public drinking water.

Controlled substances that are disposed of without prior denaturation or that accumulate in consumers' medicine cabinets often find their way into the hands of those who will use them illicitly, contributing to the ever growing drug abuse problem in the U.S. and other countries. In fact, the World Health Organization has recommended: "Controlled substances must be destroyed under supervisions of a pharmacist or the police depending on national regulations. Such substances must not be allowed into the public domain as they may be abused. They should either be rendered unusable, by encapsulation or inertization, and then dispersed among the municipal solid waste in a landfill, or incinerated."³ Accordingly, numerous products for the destruction of drugs have been developed and are currently on the market, including the *Pill Terminator* (Combined Distributors Inc.).

The *Pill Terminator* is a drug destruction kit that was developed to chemically breakdown the drug within it, rendering the drug inactive and safe for disposal. Traynor developed and reported on a method for assessing whether several commercially available kits actually destroy or denature the drugs within them or simply dissolve and encapsulate the active drug within a gel matrix.¹ In a separate, unpublished report, Traynor's methodology was used to test the efficacy of the *Pill Terminator*, which was demonstrated to destroy >98% of a sample of morphine within 48 h after mixing the drug sample with the contents of the kit (2 min spatula mixing followed by 30 min on a mechanical roller mixer).⁴ We decided to look more closely at Traynor's results to determine if similar outcomes were

obtainable in a more "real-world" setting when thorough mixing is not done. Herein, we report the *Pill Terminator*'s efficacy in degrading a sample of morphine without mixing or stirring.

Materials and Methods

Mobile Phase Preparation: A 20 mM solution of potassium phosphate dihydrogen was prepared by weighing 5.436 g of powder into a 2L volumetric flask. The 2L volume was made up using deionized water and the solution was stirred until all powder was dissolved completely. The solution was then vacuum filtered through a 0.45 μ M nylon membrane.

Analytical method development: The HPLC specifications were adapted from Traynor.^{1,4}

Preparation of morphine standards: Morphine standards in concentrations of 1-100 μ g/mL were prepared by weighing 5.002 mg of morphine directly into a 5 mL volumetric flask which was then made up to volume with deionized water to have a stock solution of 1000 μ g/mL. The standards (100, 10, and 1 μ g/mL) were prepared by serial dilution of stock solution. One set of standard concentration solutions was used to develop the calibration curve of morphine based on the HPLC method described by Traynor.^{1,4}

Destruction of Morphine: The ability of the *Pill Terminator* kit to destroy a controlled drug placed within it was assessed using the method described by Traynor, with morphine as a model drug.¹ Initially, a *Pill Terminator* bottle was shaken vigorously for 2 min to ensure homogeneity. Into a glass vial was added 1.0294g of the *Pill Terminator* solid and 0.0102 g of morphine, and the mixture shaken for 15 s. To this solid mix was added 8.5312g of water. A pink gel immediately formed (here forth this vial will be called test vial). The test vial was shaken vigorously then placed on a roller for 2 h. After this, a 1.0181 g aliquot was taken from the test vial and weighed directly into a 100 mL volumetric flask; the volume in the flask was made up using deionized water. A small magnetic stir bar was then added and the volumetric placed on a magnetic stirrer and left for 2 h, after which all the gel had visibly dissolved. Three aliquots were then taken from the volumetric flask, filtered, dispensed into HPLC vials for analysis by HPLC as the T = 0 h samples. After 48 h, the test vial was re-sampled by taking a 1.0097 g aliquot, weighing directly into a 100 mL volumetric flask, and making up the volume using deionized water. A small magnetic stir bar was then added and the volumetric placed on a magnetic stirrer and left for 2 h, after which all the gel had visibly dissolved. Three aliquots were then taken from

the volumetric flask, filtered, and dispensed into HPLC vials for analysis by HPLC and as the T = 48 h samples.

Results and Discussion

A typical chromatogram of morphine with a retention time of about 4 min is shown in Figure 1, while Figure 2 shows an HPLC calibration curve for the morphine standards. Representative chromatograms of the sample mixtures at 0 h and 48 h are shown in Figures 3 and 4, respectively.

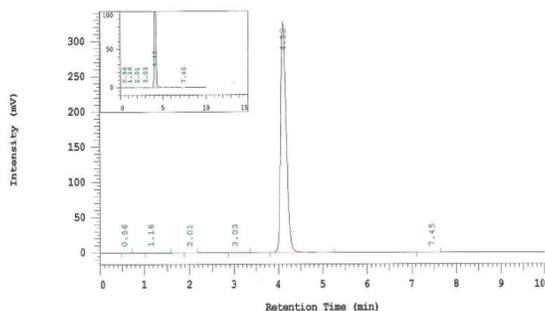


Figure 1. HPLC of 1 mg/mL morphine

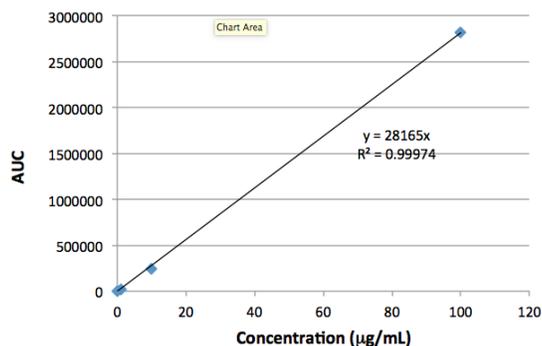


Figure 2. Calibration curve for morphine

The morphine content in three samples of the test mixture was measured at 0 h by HPLC as shown in Table 1. The morphine content in three additional samples of the test mixture was measured at 48 h by HPLC and expressed as a percentage of the morphine content at 48 h (Table 1).

Table 1. Content of Morphine in the *Pill Terminator* kit

	Morphine content (%)	
	T = 0 h	T = 48 h*
1 st Aliquot	56.6	45.3
2 nd Aliquot	57.5	46.9
3 rd Aliquot	55.9	43.5
Mean	56.6	45.2
SD	0.8	1.7

*Expressed as % morphine content at 48 h

On average, nearly half of the morphine content of the sample was destroyed immediately upon exposure to the *Pill Terminator* kit (56.6% remaining at T = 0 h) with an additional 11% destroyed after 48 h (45.2% remaining at T = 48 h). Thus, the kit appears to be instantaneously effective and continues to work even without any mixing or stirring. Presumably diffusion of the morphine through the gel matrix of the kit, once activated, is slow, which accounts for the minimal change in morphine content from 0 to 48 h. As reported by Traynor, however, this can be overcome by

thoroughly mixing the drug with contents of the kit, which results in near quantitative destruction of the drug.

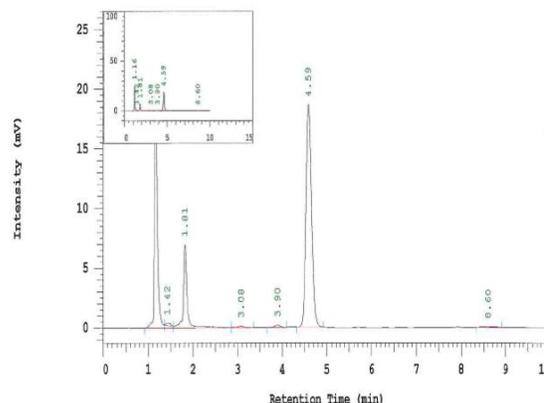


Figure 3. Sample chromatogram at T = 0 h

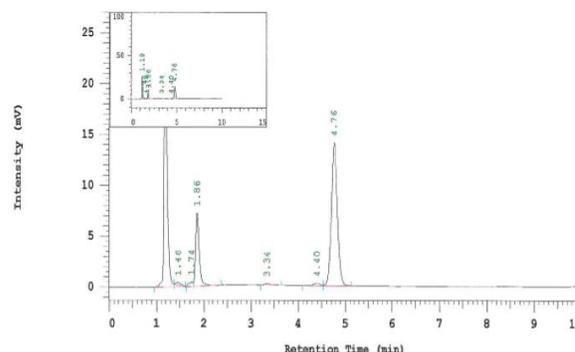


Figure 4. Sample chromatogram at T = 48 h

Conclusions

In this repeated study the *Pill Terminator* kit, manufactured by Combined Distributors Inc. USA, was shown to instantaneously destroy nearly half of an added drug sample, with an additional 11% destroyed over a period of 48 h without any stirring or mixing of the sample. Thus, while a previous study¹ reported the *Pill Terminator* kit to effectively destroy >98% of a sample of morphine after simple stirring, the kit was verified to be considerably effective without stirring, as might be the case for everyday use.

References

1. Traynor M.J., Project Report: Testing of controlled drug destruction kits. 2014, unpublished results.
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3. Gray R.C.F., Hogerzeil H.V., Pruss A.M., Rushbrook P.; World Health Organization. Guidelines for safe disposal of unwanted pharmaceuticals in and after emergencies; March 1999. Réseau Médicaments & Développement Web site. Available from: <http://apps.who.int/medicinedocs/en/d/Jwhozip51e/5.5.html> [accessed 16 October 2015].
4. Traynor M.J., Investigation into functionality of controlled drug denaturing/destruction kits. *Drug Dev Ind Pharm.* 2014, doi: 10.3109/03639045.2013.877484.