

Effect of Heating Rate on the Accuracy of Paracetamol Melting Point Determination Using a Stuart SMP3 Apparatus

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تأثير معدل التسخين على دقة تحديد درجة انصهار الباراسيتامول باستخدام جهاز SMP3 ستيوارت

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قسم الكيمياء، كلية العلوم، جامعة طبرق، طبرق، ليبيا

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Abstract

Melting-point determination is an important analytical technique for the identification of crystalline pharmaceutical substances and the assessment of their purity. This study aimed to investigate the effect of heating rate on the measured melting point of paracetamol using a Stuart SMP3 melting-point apparatus. Three commercially available paracetamol products collected from the local market in Tobruk, Libya, were coded as Brand A, Brand B, and Brand C and analyzed. Melting points were determined using the capillary method in accordance with British Pharmacopoeia (BP) and United States Pharmacopeia (USP) procedures. Three replicate measurements were performed for each brand at different controlled heating rates, and the onset and completion temperatures of melting were recorded. The results were expressed as Mean $\pm$ Standard Deviation (SD), and One-way Analysis of Variance (ANOVA) was used to evaluate differences among the different heating rates. The measured melting points were compared with the reference melting range of paracetamol (approximately 168–172°C). The results showed that increasing the heating rate generally increased the observed melting temperatures and broadened the melting range, particularly at the highest heating rate of 10°C/min. Lower heating rates produced melting-point values closer to the reference range and generally showed better measurement consistency. These findings indicate that heating rate is an important experimental factor affecting the determination of paracetamol melting point using the Stuart SMP3 apparatus. Therefore, an appropriate heating rate is recommended to achieve a balance between analytical efficiency, accuracy, and reproducibility in routine melting-point determination and pharmaceutical quality-control testing.

Keywords: paracetamol, melting point, heating rate, thermal lag, melting range, Stuart SMP3.

المخلص

يُعدّ تحديد نقطة الانصهار تقنية تحليلية مهمة لتحديد هوية المواد الصيدلانية البلورية وتقييم نقائها. هدفت هذه الدراسة إلى بحث تأثير معدل التسخين على نقطة انصهار الباراسيتامول المقاسة باستخدام جهاز ستيوارت SMP3. تم جمع ثلاثة منتجات باراسيتامول متوفرة تجاريًا من السوق المحلي في طبرق، ليبيا، وتم ترميزها بالعلامات التجارية A، B، و C، ثم تحليلها. وتم تحديد درجة الانصهار باستخدام طريقة الأنابيب الشعرية وفقًا لإجراءات دستور الأدوية البريطاني (BP) ودستور الأدوية الأمريكي (USP). أُجريت ثلاث قياسات متكررة لكل علامة تجارية بمعدلات تسخين مضبوطة مختلفة، وسُجلت درجات حرارة بدء الانصهار وانتهائه. عُرضت النتائج كمتوسط $\pm$ انحراف معياري (SD)، واستُخدم تحليل التباين أحادي الاتجاه (ANOVA) لتقييم الاختلافات بين معدلات التسخين المختلفة. فُورنت نقاط الانصهار المقاسة بنطاق الانصهار المرجعي للباراسيتامول حوالي ($168-172^\circ\text{C}$). أظهرت النتائج أن زيادة معدل التسخين تؤدي عمومًا إلى زيادة درجات حرارة الانصهار المُقاسة وتوسيع نطاق الانصهار، لا سيما عند أعلى معدل تسخين وهو 10°C/min . أما معدلات التسخين المنخفضة فتنتج قيمًا لنقطة الانصهار أقرب إلى النطاق المرجعي، وتُظهر عمومًا اتساقًا أفضل في القياس. وبالتالي تشير هذه النتائج إلى أن معدل التسخين عامل تجريبي مهم يؤثر على تحديد نقطة انصهار الباراسيتامول باستخدام جهاز ستيوارت SMP3. لذا، يُوصى باستخدام معدل تسخين مناسب لتحقيق التوازن بين الكفاءة التحليلية والدقة وقابلية التكرار في تحديد نقطة الانصهار الروتيني واختبارات مراقبة جودة المستحضرات الصيدلانية.

الكلمات المفتاحية: باراسيتامول، نقطة الانصهار، معدل التسخين، التأخر الحراري، نطاق الانصهار، ستيوارت SMP3..

Introduction

Melting point is one of the most important physical properties used in organic and pharmaceutical chemistry for the identification of crystalline solid substances and the assessment of their purity. Melting occurs when a substance changes from the solid state to the liquid state as a result of an increase in its thermal energy and reaches a specific temperature. A pure substance generally melts over a narrow temperature range, whereas the presence of impurities may disrupt the crystal lattice, resulting in a decrease in the melting point and broadening of the melting range. Therefore, melting-point determination is widely used as a preliminary test for assessing the purity of organic compounds and pharmaceutical substances. Pharmacopeial methods commonly employ the capillary method for melting-point determination, in which a small amount of finely powdered sample is placed inside a narrow capillary tube and heated under controlled conditions. Paracetamol, Chemically, it is N-(4-hydroxyphenyl) acetamide; (acetaminophen), figure (1) is one of the most widely used medications worldwide. It is commonly used as an analgesic and antipyretic and is widely administered orally. The Libyan pharmaceutical market contains numerous pharmaceutical products containing paracetamol. Paracetamol has a well-defined crystalline structure and thermal behavior that can be readily evaluated using melting-point determination apparatus. Its commonly reported melting point is approximately $169-170^\circ\text{C}$. Studies have demonstrated that paracetamol can exist in more than one crystalline form. Therefore, the crystalline form, sample purity, and thermal history may influence the thermal behavior of the material (Qi et al., 2008). one of the most important factors affecting the accuracy of melting-point determination is the heating rate. Rapid heating may cause a difference between the temperature of the sample and

the temperature of the heating block inside the apparatus. This phenomenon is known as thermal lag. when the apparatus is heated too rapidly, the temperature of the heating block may exceed 170°C, while the temperature of the material inside the capillary tube remains lower. Consequently, when the sample actually reaches its melting point, the apparatus may record a temperature higher than the true melting temperature. therefore, careful control of the heating rate is an essential factor in obtaining accurate, reliable, and reproducible melting-point measurements.

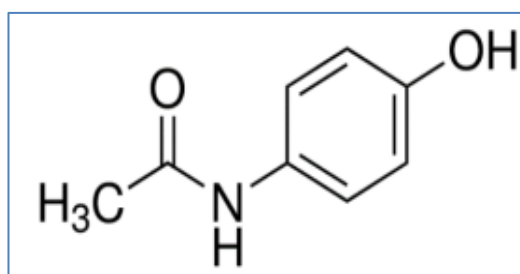


Figure 1. Structural formula of Paracetamol

Aim of the Study:

The aim of this study is to investigate the effect of different heating rates on the measured melting point of paracetamol and to compare the experimentally determined melting points with the reported reference value. The study also aims to determine the heating rate that provides the highest accuracy and reproducibility of melting-point measurements using the Stuart SMP3 melting-point apparatus.

Significance of the Study:

This study is important because accurate determination of the melting point is essential for the identification and purity assessment of pharmaceutical substances. Although the melting point of paracetamol is well established, the experimentally measured value can be affected by several factors, particularly the heating rate used during the measurement.

The significance of this study can be summarized as follows :

- 1-The study investigates how different heating rates affect the measured melting point of paracetamol and determines the extent to which rapid or slow heating influences the obtained results.
- 2-The study provides a better understanding of thermal lag, which occurs when the temperature of the sample inside the capillary tube does not immediately follow the temperature of the heating block.
- 3-Identifying an appropriate heating rate can help obtain melting-point values that are closer to the accepted reference value of paracetamol (approximately 169–170°C).

Materials and Methods

Study Samples

three different commercially available paracetamol products were collected from the local pharmaceutical market in Tobruk City, Libya for melting-point analysis. Each commercial product was assigned a coded letter to ensure consistent identification throughout the study, as presented in the corresponding table(1).The samples were analyzed by determining their melting points using a Stuart SMP3 Melting Point Apparatus. The experimental procedure was conducted in accordance with the relevant procedures described in the British Pharmacopoeia (BP) and United States Pharmacopeia (USP). The experiments were conducted in the chemistry

laboratories at the Faculty of Science at the University of Tobruk, which have the materials and the Stuart SMP3 Melting Point Apparatus.

Table1 : Brand, Dosage, Origin , Expiration Date of paracetamol

Brand	Origin	Dosage	Expiry Date
A	500mg	Ireland	9/2028
B	500mg	USA	4/2027
C	500mg	UK	10/2027

Materials

The following materials were used in the study :

Commercial paracetamol powder samples with known pharmaceutical specifications. Capillary tubes (1cm) for melting-point determination. Laboratory tissues and suitable cleaning materials.

Mortar and pestle for grinding and homogenizing the samples. Analytical balance. Stuart SMP3 Melting Point Apparatus Country of manufacture: United Kingdom. as shown in Figure 2.



Figure 2. Stuart SMP3 Melting Point Apparatus.

procedures

The apparatus is designed for controlled heating and melting-point determination. During the experiment. For each measurement, a finely powdered paracetamol sample was carefully introduced into a capillary tube. The capillary tube was then placed into the melting-point apparatus, and the sample was heated at the predetermined heating rate. The melting behavior was observed through the optical system, and the melting temperature was recorded. The use of different heating rates allowed the effect of heating rate on the observed melting point to be investigated and enabled evaluation of the relationship between heating rate, thermal lag, and observed melting point. The accuracy of the melting-point measurements was evaluated by comparing the experimentally determined melting-point values with the reported reference melting-point range of paracetamol. The commonly reported melting point for the predominant crystalline Form I of paracetamol is approximately 169–170°C.

Statistical Analysis:

All data were statistically analyzed using SPSS software. Three replicate measurements ($n = 3$) were performed for each paracetamol brand at each heating rate. The results were expressed as Mean $\pm$ Standard Deviation (SD). One-way Analysis of Variance (ANOVA) was used to compare melting-point measurements among the different heating rates. Pearson's correlation coefficient was used to assess the relationship between heating rate and melting temperature. Percentage deviation from the reference melting point was also calculated. Statistical significance was considered at $p < 0.05$.

$$\text{Percentage Deviation} = \frac{\text{Measured Melting Point} - \text{Reference Melting Point}}{\text{Reference Melting Point}} \times 100$$

Discussion of Results

Table (2) illustrates the effect of heating rate on the thermal behavior of paracetamol in by comparing the mean onset melting temperature, mean end-of-melting temperature, and melting range at different heating rates ranging from 0.5 to 10.0 °C/min. The results showed that the mean onset melting temperature was 169.2 ± 0.10 °C at a heating rate of 0.5 °C/min, followed by a slight decrease to 169.0 ± 0.10 °C at 1.0 °C/min. Thereafter, the onset melting temperature gradually increased to 169.4 ± 0.10 °C at 2.0 °C/min, 170.3 ± 0.10 °C at 5.0 °C/min, and finally 171.5 ± 0.10 °C at 10.0 °C/min. Thus, the onset melting temperature increased by 2.3 °C between the lowest and highest heating rates. This indicates that increasing the heating rate tends to increase the apparent temperature at which melting begins. Similarly, the mean end-of-melting temperature increased from 170.2 ± 0.10 °C at 0.5 °C/min to 173.1 ± 0.10 °C at 10.0 °C/min, representing an overall increase of 2.9 °C. The increase became more pronounced at the higher heating rates, particularly between 2.0 and 10.0 °C/min. This behavior may be associated with thermal lag, whereby the internal temperature of the sample does not immediately reach the temperature indicated by the instrument during rapid heating. The melting range also increased progressively from 1.0 °C at 0.5 °C/min to 1.6 °C at 10.0 °C/min. This broadening indicates that the sample requires a longer thermal period to complete the melting process at higher heating rates. It may reflect thermal non-uniformity within the sample or delayed heat transfer from the heating medium to the sample. It is noteworthy that heating rates of 0.5 and 1.0 °C/min produced relatively narrow melting ranges, while the melting range at 2.0 °C/min remained close to these values at 1.1 °C. In contrast, the range increased to 1.3 °C at 5.0 °C/min and to 1.6 °C at 10.0 °C/min. This suggests that low to moderate heating rates provide better conditions for obtaining a clear and accurate melting point. Overall, the results presented in Table (2) demonstrate that heating rate clearly affects the measured melting behavior of Brand A. Higher heating rates may result in an increase in the apparent melting temperature and broadening of the melting range, whereas slower heating rates, particularly 0.5–2.0 °C/min, appear more suitable for obtaining accurate and reproducible measurements.

Table 2. Melting Behavior of Paracetamol Brand A at Different Heating Rates.

Heating rate (°C/min)	Mean onset melting temperature (°C)	Mean end-of-melting temperature (°C)	Melting range (°C)
0.5	169.2 ± 0.10	170.2 ± 0.10	1.0
1.0	169.0 ± 0.10	170.1 ± 0.10	1.1
2.0	169.4 ± 0.10	170.5 ± 0.10	1.1
5.0	170.3 ± 0.10	171.6 ± 0.10	1.3
10.0	171.5 ± 0.10	173.1 ± 0.10	1.6

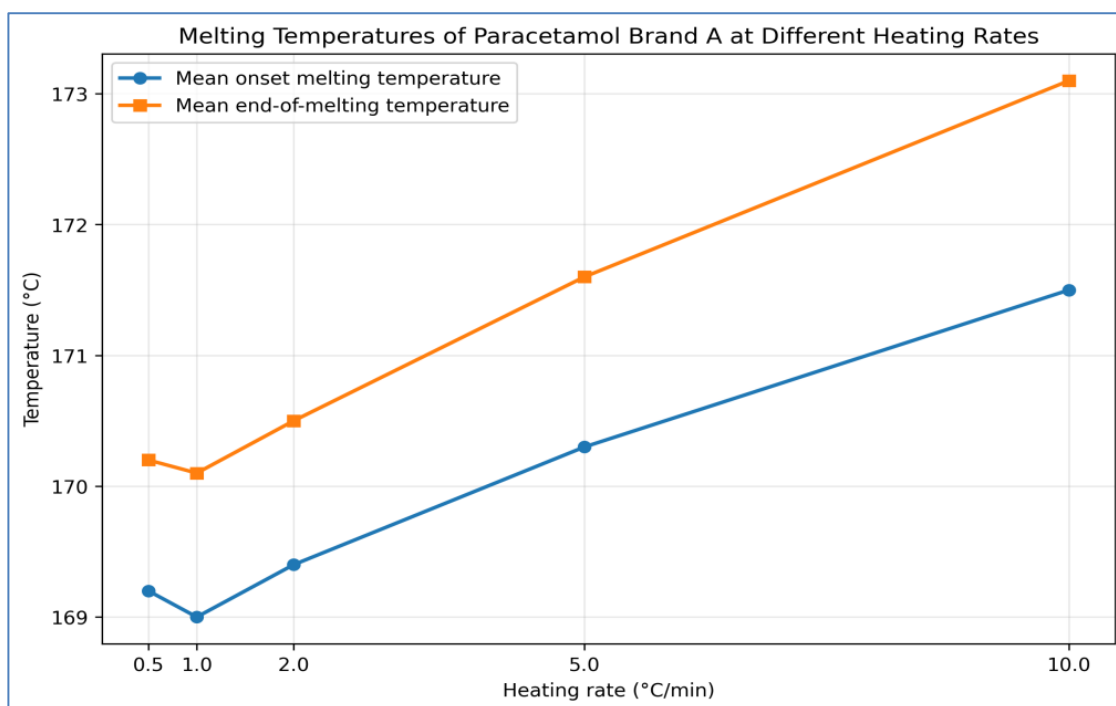


Figure 3. Melting Temperatures of Paracetamol Brand A at Different Heating Rates.

Table (3) shows that the melting temperatures of Brand B were slightly higher than those observed for Brand A at several corresponding heating rates. The results indicate a general relationship between increasing heating rate and increasing onset and end-of-melting temperatures, accompanied by a broadening of the melting range. The mean onset melting temperature was 169.8 ± 0.10 °C at 0.5 °C/min and decreased slightly to 169.5 ± 0.10 °C at 1.0 °C/min. Thereafter, it increased to 169.9 ± 0.10 °C at 2.0 °C/min, 170.8 ± 0.10 °C at 5.0 °C/min, and finally 172.0 ± 0.10 °C at 10.0 °C/min. Thus, the difference between the lowest and highest heating rates was 2.2 °C. The slight decrease between 0.5 and 1.0 °C/min does not contradict the overall trend and may be attributed to normal experimental variation. Beyond 1.0 °C/min, a clear increasing trend was observed with increasing heating rate. The mean end-of-melting temperature increased from 170.9 ± 0.10 °C at 0.5 °C/min to 173.7 ± 0.10 °C at 10.0 °C/min, representing an overall increase of 2.8 °C. This increase indicates that rapid heating results in a higher recorded temperature at the completion of melting compared with slower heating. The melting range also showed a gradual increase. It was 1.1 °C at both 0.5 and 1.0 °C/min, increased to 1.2 °C at 2.0 °C/min, 1.3 °C at 5.0 °C/min, and reached 1.7 °C at 10.0 °C/min. The broadening of the melting range with increasing heating rate is an important indication of reduced sharpness in the melting transition at higher heating rates. The results demonstrate that heating rates of 0.5–1.0 °C/min produced a relatively narrow and stable melting range, whereas differences became more apparent at 5.0 and 10.0 °C/min. This can be explained by the fact that rapid heating does not allow the sample to reach thermal equilibrium before the instrument temperature continues to rise, resulting in delayed melting of some portions of the sample and consequently higher recorded temperatures. Therefore, the results in Table (3) demonstrate a pattern consistent with the expected effect of heating rate: as the heating rate increases, the apparent melting temperatures increase and the melting range becomes broader. Accordingly,

low to moderate heating rates, particularly 0.5–2.0 °C/min, appear more suitable for obtaining accurate and reproducible melting-point measurements.

Table 3. Melting Behavior of Paracetamol Brand B at Different Heating Rates

Heating rate (°C/min)	Mean onset melting temperature (°C)	Mean end-of-melting temperature (°C)	Melting range (°C)
0.5	169.8 ± 0.10	170.9 ± 0.10	1.1
1.0	169.5 ± 0.10	170.6 ± 0.10	1.1
2.0	169.9 ± 0.10	171.1 ± 0.10	1.2
5.0	170.8 ± 0.10	172.1 ± 0.10	1.3
10.0	172.0 ± 0.10	173.7 ± 0.10	1.7

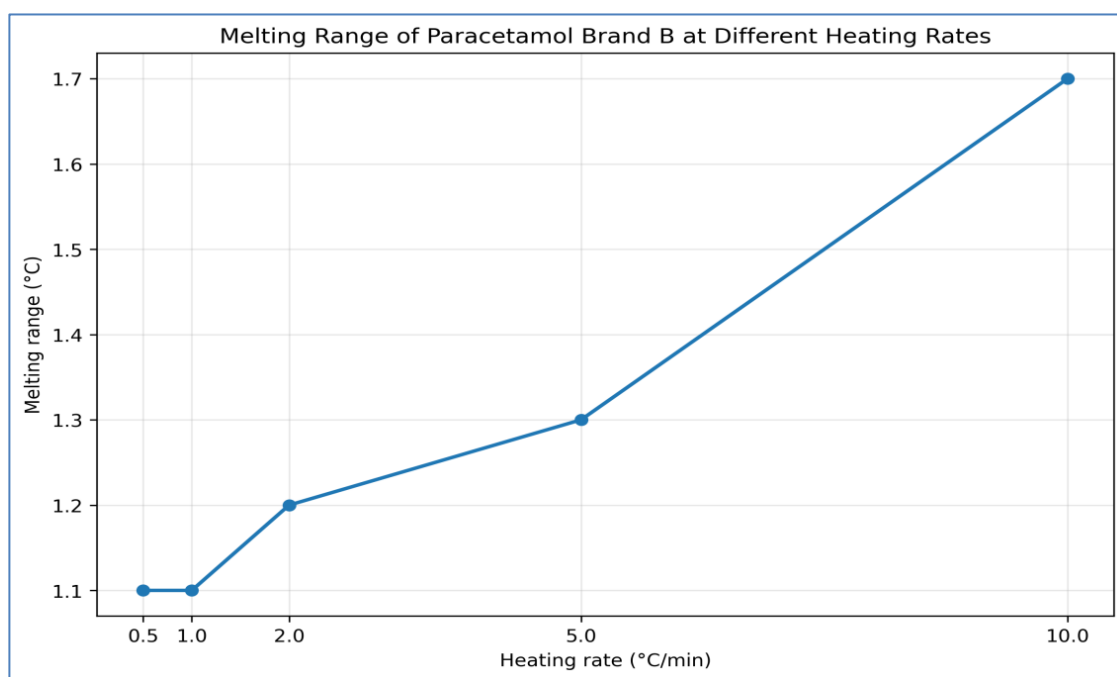


Figure 4. Melting Range of Paracetamol Brand B at Different Heating Rates

Table (4) demonstrates the effect of heating rate on the thermal behavior of paracetamol Brand C. The results show a general trend of increasing melting temperature and broadening of the melting range as the heating rate increases. The mean onset melting temperature was 170.0 ± 0.10 °C at 0.5 °C/min and decreased slightly to 169.7 ± 0.10 °C at 1.0 °C/min. It subsequently increased to 170.1 ± 0.10 °C at 2.0 °C/min, 171.0 ± 0.10 °C at 5.0 °C/min, and finally 172.3 ± 0.10 °C at 10.0 °C/min. Therefore, the increase between the lowest and highest heating rates was 2.3 °C. The mean end-of-melting temperature increased from 171.1 ± 0.10 °C at 0.5 °C/min to 174.1 ± 0.10 °C at 10.0 °C/min, representing an overall increase of 3.0 °C. This was the largest increase in end-of-melting temperature among the three brands presented in the tables. The melting range also showed a clear change with heating rate. It was 1.1 °C at both 0.5 and 1.0 °C/min, increased to 1.2 °C at 2.0 °C/min, 1.4 °C at 5.0 °C/min, and reached 1.8 °C at 10.0 °C/min. Thus, the melting range increased by 0.7 °C between the lowest and highest heating rates. This broadening of the melting range indicates that rapid heating reduces the sharpness of the transition from the solid to the liquid state. At high heating rates, the temperature of the

instrument may become higher than the actual uniform temperature within the sample. Consequently, the instrument continues to record an increasing temperature before all portions of the sample have completely melted. This results in a higher apparent melting temperature and a broader melting range. The results obtained at 0.5–2.0 °C/min were more closely grouped, with melting ranges between 1.1 and 1.2 °C. This suggests that slow heating allows more uniform heat transfer throughout the sample and provides a clearer determination of the melting point. Furthermore, Brand C exhibited the largest melting range at the highest heating rate, reaching 1.8 °C, compared with 1.6 °C for Brand A and 1.7 °C for Brand B. This suggests that the effect of high heating rates was most pronounced in Brand C. Overall, the results indicate that the three paracetamol brands exhibited a similar general response to increasing heating rate. However, the magnitude of the changes differed slightly among the brands. These differences may be related to variations in sample purity, excipients, particle characteristics, or solid-state properties among the commercial formulations. The overall findings support the use of low to moderate heating rates, particularly 0.5–2.0 °C/min, when accurate and reproducible determination of the melting point of paracetamol is required.

Table 4. Melting Behavior of Paracetamol Brand C at Different Heating Rates

Heating rate (°C/min)	Mean onset melting temperature (°C)	Mean end-of-melting temperature (°C)	Melting range (°C)
0.5	170.0 ± 0.10	171.1 ± 0.10	1.1
1.0	169.7 ± 0.10	170.8 ± 0.10	1.1
2.0	170.1 ± 0.10	171.3 ± 0.10	1.2
5.0	171.0 ± 0.10	172.4 ± 0.10	1.4
10.0	172.3 ± 0.10	174.1 ± 0.10	1.8

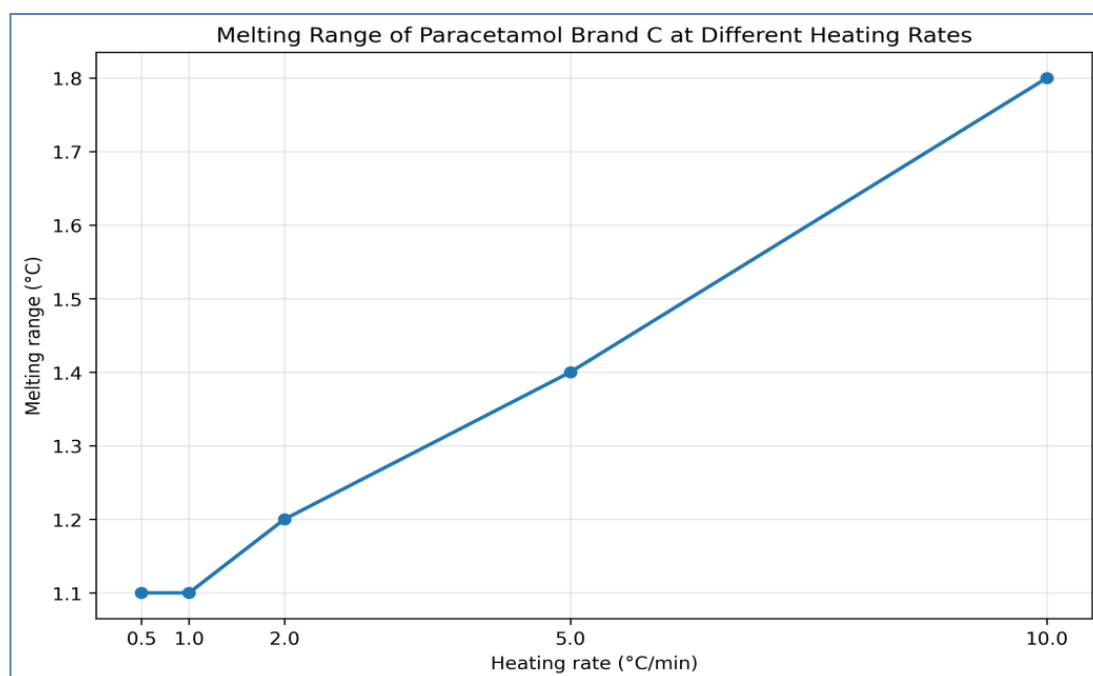


Figure 5. Melting Range of Paracetamol Brand C at Different Heating Rates.

Conclusion

The present study demonstrated that the heating rate is an important experimental factor in the determination of the melting behavior of commercial paracetamol using the Stuart SMP3 apparatus. The three investigated paracetamol brands showed a general increase in the observed melting temperatures as the heating rate increased. In addition, higher heating rates, particularly 5 and 10 °C/min, were associated with broader melting ranges, whereas lower heating rates produced narrower ranges and values generally closer to the reference melting range of paracetamol. The observed differences in melting behavior may be attributed mainly to thermal lag during rapid heating, in which the temperature of the sample does not immediately reach thermal equilibrium with the surrounding heating medium. These findings indicate that the selection of an appropriate heating rate is essential for obtaining reliable and reproducible melting-point measurements. Overall, lower heating rates, particularly within the range of 0.5–2.0 °C/min, appear to be more suitable when accuracy and reproducibility are prioritized, while higher heating rates may be useful when rapid screening is required but can result in an overestimation of the apparent melting temperature and an increased melting range. Therefore, careful control and standardization of the heating rate and sample preparation conditions are recommended for routine melting-point determination of paracetamol using the Stuart SMP3 apparatus.

Summary

This study investigated the effect of heating rate on the melting point of three commercial paracetamol brands using the Stuart SMP3 apparatus. Melting points were measured at 0.5, 1, 2, 5, and 10°C/min using the capillary method. The results showed that higher heating rates generally increased the observed melting temperature and broadened the melting range, particularly at 10°C/min. Lower heating rates produced values closer to the reference range and better reproducibility. These findings indicate that heating rate is an important factor in obtaining accurate and reliable melting-point measurements.

Recommendations

- 1-Periodic calibration of the Stuart SMP3 device should be performed to ensure measurement accuracy and reliability. The results obtained using the SMP3 should also be compared periodically with those obtained using Differential Scanning Calorimetry (DSC) as a reference thermal analysis technique.
- 2-High heating rates should be avoided when accurate and precise melting-point measurements are required, as rapid heating may result in higher observed melting temperatures and broader melting ranges.
- 3-The height of the sample inside the capillary tube should be standardized during all measurements to minimize variations in heat transfer and ensure better reproducibility between measurements.
- 4-Future studies should include a larger number of paracetamol brands and commercial formulations, with particular attention to the effects of excipients, impurities, polymorphic forms, particle characteristics, and other physical and crystalline properties on the observed melting point.
- 5-Comparative statistical analyses should be performed between heating rates and commercial brands to determine whether differences in the onset and end-of-melting temperatures are statistically significant, rather than relying solely on descriptive differences between the measured values

6-Further research is recommended to investigate the relationship between heating rate, sample purity, polymorphism, and thermal history in order to better understand their combined effects on the melting behavior of paracetamol.

References

- 1-Ahmad, I.; Shaikh, R. H. Effect of temperature and humidity on hardness and friability of packaged paracetamol tablet formulations. *Pak. J. Pharm. Sci.* 1993, 7 (2), 69–78.
- 2-Akasha., A, Ahdeya., E, Bsebsu ., Z . (2019) Comparative study between five brands of metformin hydrochloride available in Libyan drug market. *Mintage Journal of Pharmaceutical and Medical Sciences.* 8 (3) 37-41
- 3-Acetaminophen capsules. (2019). In United States Pharmacopeia Convention Committee of Revision (Ed.), *United States Pharmacopeia - National Formulary* (41st ed., p. 8). United States Pharmacopeial Convention.
- 4-Boldyreva, E. V., Drebuschak, T. N., Paukov, I. E., Kovalevskaya, Y. A., & Drebuschak, V. A. (2004). DSC and adiabatic calorimetry study of the polymorphs of paracetamol: An old problem revisited. *Journal of Thermal Analysis and Calorimetry*, 77, 607–623.
- 5-British Pharmacopoeia , (2017) and beyond. *European Pharm Rev.* 2017 ; 22:14-6 tablets, the Stationery Office..
- 6-Council of Europe. *European Pharmacopoeia*. 6th ed. Strasbourg: Council of Europe; 2007. Paracetamol; p. 2611.
- 7-European Pharmacopoeia. Paracetamol, Monograph 0049. European Directorate for the Quality of Medicines & HealthCare (EDQM), Council of Europe
- 8-Espeau, P., Ceolin, R., Roblès, R., & others. (2005). Polymorphism of paracetamol: Relative stabilities of the monoclinic and orthorhombic phases inferred from topological pressure-temperature and temperature-volume phase diagrams. *Journal of Pharmaceutical Sciences*, 94(3), 524–539.
- 9-Gunatilake, S. K., Samarasinghe, S. S., Adekola, F.A. (2016). Effects of binder on the physico-chemical properties and the quality of paracetamol tablets. *Der Pharm Chem.* 8, 237-42
- 10-Global Surveillance and Monitoring System for Substandard and Falsified Medical Products. World Health Organization: Geneva, 2017.
- 11-Gaisford, S., Buanz, A. B. M., & Jethwa, N. (2010). Characterisation of paracetamol form III with rapid-heating DSC. *Journal of Pharmaceutical and Biomedical Analysis*, 53(3), 366–370.
- 12-Khan AD, Baranwal PK, Ali MA, Kumar S, Sharma S (2019) Comparative quality evaluation of two brands of paracetamol tablets obtained from the market. *International Journal of Pharmaceutical Education and Research.* 1 (1): 14-18.
- 13-Reem .,A, Syed ., N , Muhammad .M ., (2021) Quality assessment of nine paracetamol 500 mg tablet brands marketed in Saudi Arabia. *BMC Res Notes.* 2021; 14: 254-258.
- 14-Ruwida., K , Entesar., E , Asma .,E. (2024). Physical and Chemical Evaluation of Different Brands of Paracetamol Tablets, *journal Alqalam Med App Sci.* 2024;7(2), 257-260.
- 15-Rassat, M., Ouandji, I., Guiblin, N., & Espeau, P. (2024). Obtaining two polymorphic forms of paracetamol within the phase diagram with PEG 1500. *European Journal of Pharmaceutics and Biopharmaceutics*, 195.
- 16-Stuart Equipment. SMP3 Melting Point Apparatus: Operating Instructions. Stuart/Barloworld Scientific .

- 17-Some, I.T., Bogaerts, P., Hanus, R., Hanocq, M., Dubois, J. (2001). Stability parameter estimation at ambient temperature from studies at elevated temperatures. *Journal of pharmaceutical sciences*. 90(11):1759-1766.
- 18-U.S. Food and Drug Administration (FDA). (2024). Q2(R2) Validation of Analytical Procedures: Guidance for Industry.
- 19-Mukesh, P. Ratnaparkhi, Shilpa P. Chaudhari, Suresh B. Dhiwar RRG. Marketed Formulations: Quality Evaluation of Conventional Release Paracetamol Tablet. *Res J Pharm Tech*. 2012, 5 (3), 390–392 .
- 20- Qi, S., Avale, P., Saklatvala, R., & Craig, D. (2008). An investigation into the effects of thermal history on the crystallisation behaviour of amorphous paracetamol. *European Journal of Pharmaceutics*.

Compliance with ethical standards***Disclosure of conflict of interest***

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