ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug1210

Comparison of Degradation Studies and Stability of Antidepressant Tablets by Using UV Visible Spectroscopy

A. A. Sivabalan[1]; Tamilselvan C.[2]; Tamizharasi A.[2]; Vignesh N.[2]; Vigneshwaran S.[2]; Vinodini S.[2]; P. Vaijayanthimala[2]; B. Sangameswaran[2]

[1]Professor, Department of Pharmaceutical Chemistry, SSM College of Pharmacy, Bhavani, Erode
[2]SSM College of Pharmacy, the Tamil Nadu Dr. M.G.R. Medical University, Jambai, Erode

Publication Date: 2026/09/02

Abstract: Chemical stability under both harsh and everyday storage conditions is a decisive factor in whether an antidepressant tablet can be relied upon to deliver a consistent dose over its shelf life. This work compares how five commonly dispensed antidepressants – Fluoxetine Hydrochloride, Duloxetine Hydrochloride, Amitriptyline Hydrochloride, Selegiline Hydrochloride and Mirtazapine – behave when pushed hard by stress testing and, separately, when simply left on the bench for a week. Absorbance loss at each drug's own wavelength of maximum absorption was tracked by UV-Visible spectrophotometry after acid, base, peroxide, heat and light exposure, and again, day by day, under ordinary room conditions. Acid hit Amitriptyline hardest (64.18% loss); alkali was harshest on Selegiline (72.41%); peroxide affected Fluoxetine most (35.02%); and heat and light both took the greatest toll on Duloxetine (78.26% and 37.39%, respectively). Taking the five stress tests together, Selegiline and Mirtazapine held up best on average, while Fluoxetine and Duloxetine proved the most fragile. A separate seven-day shelf study, run against calibration curves with near-perfect linearity ($R^2 \geq 0.999$) for every drug, told much the same story on a smaller scale: drug content after a week ranged from 94.41% for Duloxetine, the weakest performer, up to 98.36% for Selegiline, the strongest. The two data sets line up well – Selegiline came out on top in both, Duloxetine at the bottom in both – which suggests the forced-degradation ranking is a genuine reflection of each drug's underlying chemical robustness rather than a one-off result. Taken together, the findings support UV spectrophotometry as an economical, quick and dependable way to screen and compare the stability of antidepressant formulations.

Keywords: *Antidepressants; UV-Visible Spectrophotometry; Forced Degradation; Stability Testing; Fluoxetine; Duloxetine; Amitriptyline; Selegiline; Mirtazapine*.

How to Cite: A. A. Sivabalan; Tamilselvan C.; Tamizharasi A.; Vignesh N.; Vigneshwaran S.; Vinodini S.; P. Vaijayanthimala; B. Sangameswaran (2026) Comparison of Degradation Studies and Stability of Antidepressant Tablets by Using UV Visible Spectroscopy. *International Journal of Innovative Science and Research Technology*, 11(8), 2439-2444. https://doi.org/10.38124/ijisrt/26aug1210

I. INTRODUCTION

Few areas of medicine treat as many people, for as long, as depression does. Drug treatment sits at the centre of managing it, and the prescribing landscape today draws on several distinct pharmacological families rather than one dominant class. The present work looks at five such agents – Fluoxetine Hydrochloride from the SSRI group, Duloxetine Hydrochloride from the SNRIs, the tricyclic Amitriptyline Hydrochloride, the MAO-B inhibitor Selegiline Hydrochloride, and Mirtazapine, a noradrenergic and serotonin-specific agent. Whatever their differing mechanisms, all five share one requirement: the tablet in the patient's hand must still contain the drug it claims to, in a chemically intact form, at the time it is taken.

That requirement is what forced-degradation and stability testing are designed to check. ICH guidance (Q1A(R2), and the companion recommendations on stress testing) calls for a new drug substance to be deliberately pushed through acid, base, oxidant, heat and light exposure so that its breakdown pathways are known in advance, and so that whichever analytical method is later used for routine assay can be shown to actually distinguish the parent drug from what it turns into. That is the harsh-condition side of the picture. The other side is more mundane – how much does a tablet lose simply sitting at room temperature for a few days – and it is this everyday robustness that determines whether a formulation is fit for the pharmacy shelf and the patient's cabinet, not just the stress chamber.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug1210

UV-Visible spectrophotometry lends itself readily to both questions. Each of the five drugs studied here carries an aromatic system that absorbs strongly somewhere in the 200–300 nm window, so a fall in absorbance at that wavelength after a stress treatment can be read directly as a loss of intact drug. Against HPLC or LC-MS, the trade-off is straightforward: UV work sacrifices the ability to identify individual breakdown products, but in exchange it needs no expensive column, no gradient method development, and only minutes of instrument time per sample – a real advantage when five drugs and five stress conditions have to be screened side by side.

Published work tends to treat these drugs one at a time – a validated UV or HPLC method for Fluoxetine here, a stability-indicating assay for Duloxetine there – and a head-to-head comparison across several pharmacologically unrelated antidepressants, run under one common protocol, is harder to find. That gap is what this study addresses: the acidic, alkaline, oxidative, thermal and photolytic degradation behaviour of marketed Fluoxetine, Duloxetine, Amitriptyline, Selegiline and Mirtazapine tablets, together with their seven-day storage stability under ambient conditions, all measured by UV-Visible spectrophotometry and set alongside one another.

II. MATERIALS AND METHODS

➢ *Drugs, Reagents and Instruments*

Commercial tablet brands of the five drugs – Fluoxetine Hydrochloride, Duloxetine Hydrochloride, Amitriptyline Hydrochloride, Selegiline Hydrochloride and Mirtazapine – were sourced locally and used as received. Methanol and distilled water (AR grade) covered the routine solvent needs; 0.1 N HCl and 0.1 N NaOH provided the acidic and alkaline stress, and 3% v/v hydrogen peroxide the oxidative stress. Absorbance readings were taken on a double-beam UV-Visible spectrophotometer with matched 1 cm quartz cells, alongside a digital analytical balance, a thermostatted water bath, a hot-air oven for the thermal run and a UV cabinet for the photolytic one, plus standard volumetric glassware throughout.

➢ *General Procedure*

For each drug, powdered tablet equivalent to 10 mg of active ingredient went into solution and was scanned across 200–400 nm to confirm λmax – 227 nm for Fluoxetine, 289 nm for Duloxetine, 239 nm for Amitriptyline, 210 nm for Selegiline and 290 nm for Mirtazapine, values that matched earlier physicochemical characterisation of the same formulations. This working solution then went through each of the five stress treatments in turn, with absorbance recorded at the drug's own λmax both before (A_0) and after (A_t) exposure. Percentage loss was worked out from Equation (1):

$$\% \text{ Degradation} = [(A_0 - A_t) / A_0] \times 100 \quad \ldots \quad (1)$$

➢ *Forced Degradation Conditions*

For the acid run, the working solution was combined 1:1 with 0.1 N HCl and held at 60°C for two hours before neutralisation with 0.1 N NaOH. The alkaline run mirrored this, substituting 0.1 N NaOH for the stress and neutralising with 0.1 N HCl afterward. Oxidative stress meant two hours at room temperature with 3% v/v H_2O_2 added to the solution. For thermal stress, powdered tablet material – rather than a solution – sat in a hot-air oven at 60°C for 24 hours before being reconstituted; the photolytic run used the same 24-hour window but under UV/sunlight exposure instead of heat. In every case the treated material was diluted to a measurable range and read against an appropriate blank at the relevant λmax.

➢ *Calibration Curve and Short-Term Stability Study*

Five standard solutions – 10, 20, 30, 40 and 50 µg/mL, prepared from the stock – gave each drug its own calibration line, absorbance plotted against concentration and fitted by simple linear regression (A = mC + c). For the stability arm of the study, powdered tablet equivalent to 30 mg of drug was dissolved and diluted down to a 30 µg/mL working strength, sitting comfortably inside the calibration range, and this solution was freshly made up and read once a day for eight consecutive days (Day 0 through Day 7) while the bulk sample was left under normal ambient laboratory conditions between readings. Each day's absorbance was converted back to a concentration using the calibration equation (C = (A − c)/m), and the drug remaining and drug lost, relative to Day 0, followed from Equations (2) and (3):

$$\% \text{ Drug remaining} = (C_n / C_0) \times 100 \quad (2)$$

$$\% \text{ Degradation} = 100 - \% \text{ Drug remaining} \quad (3)$$

III. RESULTS

➢ *Forced Degradation Studies*

No drug came out worst – or best – across the board; which one took the biggest hit depended entirely on which stress was applied (Table 1). Acid was unkindest to Amitriptyline, stripping away 64.18% of its absorbance, while Duloxetine barely noticed it (24.35%). Flip to alkali and the ranking turns almost upside down: Selegiline lost the most (72.41%), Amitriptyline the least (8.21%). Peroxide told a different story again – Fluoxetine was the most reactive (35.02%), Duloxetine the least (11.30%). Heat proved punishing for Duloxetine (78.26% loss, the single largest figure recorded anywhere in this study), with Selegiline comparatively unaffected (23.44%). Light exposure repeated the thermal pattern almost exactly: Duloxetine again the heaviest loser (37.39%), Selegiline the clear standout for photostability (2.30%).

Table 1 Percentage Degradation of the Five Antidepressant Drugs Under Acidic, Alkaline, Oxidative, Thermal and Photolytic Stress Conditions

Stress Condition	Fluoxetine	Duloxetine	Amitriptyline	Selegiline	Mirtazapine
Acidic (0.1N HCl, 60°C, 2h)	60.94	24.35	64.18	34.48	47.95
Alkaline (0.1N NaOH, 60°C, 2h)	69.02	71.30	8.21	72.41	27.40

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug1210

Oxidative (3% H_2O_2, RT, 2h)	35.02	11.30	27.61	18.39	30.14
Thermal (60°C, 24h)	41.75	78.26	70.89	23.44	41.10
Photolytic (UV/sunlight, 24h)	15.82	37.39	10.45	2.30	5.48
Mean % degradation	44.51	44.52	36.27	30.20	30.41

Table 2 Drug Showing the Largest and Smallest Loss Under Each Stress Condition

Stress Condition	Worst-affected drug (%)	Most resistant drug (%)
Acidic	Amitriptyline (64.18)	Duloxetine (24.35)
Alkaline	Selegiline (72.41)	Amitriptyline (8.21)
Oxidative	Fluoxetine (35.02)	Duloxetine (11.30)
Thermal	Duloxetine (78.26)	Selegiline (23.44)
Photolytic	Duloxetine (37.39)	Selegiline (2.30)

➢ *Calibration Curves*

Every drug produced a straight-line response across the 10–50 µg/mL range at its own λmax, with R^2 values sitting at 1.0000 or a hair below it (Table 3) – close enough to the Beer-Lambert ideal that the resulting equations could be trusted to back-calculate concentration in the stability samples without introducing meaningful error of their own.

Table 3 Calibration Curve Parameters (10–50 µg/mL) for the Five Study Drugs

Drug	λmax (nm)	Regression Equation	R^2
Fluoxetine HCl	227	A = 0.0648C − 0.0005	1.0000
Duloxetine HCl	289	A = 0.0632C − 0.0007	1.0000
Amitriptyline HCl	239	A = 0.0724C − 0.0002	1.0000
Selegiline HCl	210	A = 0.0631C − 0.0011	1.0000
Mirtazapine	290	A = 0.0683C + 0.0027	1.0000

➢ *Seven-Day Ambient Stability*

Left on the bench rather than pushed through a stress chamber, all five tablets behaved far more gently – concentration eased downward gradually over the week, with nothing resembling the sharp drops seen under forced conditions (Table 4). Selegiline finished the week having lost the least drug of all (98.36% remaining, 1.64% gone), with Mirtazapine (98.00%) and Amitriptyline (97.61%) close behind. Fluoxetine trailed a little further back at 96.19%, and Duloxetine brought up the rear at 94.41% – a 5.59% loss, the largest recorded in this part of the study.

Table 4 Percentage Drug Remaining on Days 0, 3, 5 and 7 of Ambient Stability Monitoring

Drug	Day 0 (%)	Day 3 (%)	Day 5 (%)	Day 7 (%)	% Lost by Day 7
Fluoxetine HCl	100.00	98.35	97.27	96.19	3.81
Duloxetine HCl	100.00	97.57	95.99	94.41	5.59
Amitriptyline HCl	100.00	98.99	98.30	97.61	2.39
Selegiline HCl	100.00	99.31	98.84	98.36	1.64
Mirtazapine	100.00	99.17	98.58	98.00	2.00

➢ *Day-by-Day Stability Profile of Individual Drugs*

Breaking the seven-day trend down day by day (Table 5) confirms that the decline was smooth for every drug studied – there is no point in any dataset where concentration falls off a cliff between two consecutive readings. That pattern rules out any batch-specific mishap or measurement anomaly and instead points to ordinary, slow chemical change as the explanation for the losses recorded.

Table 5 Day-by-Day Stability Data – Fluoxetine Hydrochloride (227 nm)

Day	Absorbance	Concentration (µg/mL)	% Drug Remaining
Day 0	1.944	30.00	100.00
Day 1	1.933	29.83	99.43
Day 2	1.922	29.66	98.87
Day 3	1.912	29.51	98.35
Day 4	1.901	29.34	97.79
Day 5	1.891	29.19	97.27
Day 6	1.880	29.02	96.71
Day 7	1.870	28.86	96.19

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug1210

Table 6 Day-by-Day Stability Data – Duloxetine Hydrochloride (289 nm)

Day	Absorbance	Concentration (µg/mL)	% Drug Remaining
Day 0	1.896	30.00	100.00
Day 1	1.881	29.76	99.21
Day 2	1.865	29.51	98.37
Day 3	1.850	29.27	97.57
Day 4	1.835	29.03	96.78
Day 5	1.820	28.79	95.99
Day 6	1.805	28.56	95.20
Day 7	1.790	28.32	94.41

Table 7 Day-by-Day Stability Data – Amitriptyline Hydrochloride (239 nm)

Day	Absorbance	Concentration (µg/mL)	% Drug Remaining
Day 0	2.172	29.99	100.00
Day 1	2.165	29.90	99.68
Day 2	2.157	29.79	99.31
Day 3	2.150	29.69	98.99
Day 4	2.142	29.58	98.62
Day 5	2.135	29.48	98.30
Day 6	2.128	29.39	97.97
Day 7	2.120	29.28	97.61

Table 8 Day-by-Day Stability Data – Selegiline Hydrochloride (210 nm)

Day	Absorbance	Concentration (µg/mL)	% Drug Remaining
Day 0	1.893	30.00	100.00
Day 1	1.888	29.92	99.74
Day 2	1.884	29.86	99.52
Day 3	1.880	29.80	99.31
Day 4	1.875	29.72	99.05
Day 5	1.871	29.65	98.84
Day 6	1.867	29.59	98.63
Day 7	1.862	29.51	98.36

Table 9 Day-by-Day Stability Data – Mirtazapine (290 nm)

Day	Absorbance	Concentration (µg/mL)	% Drug Remaining
Day 0	2.051	29.99	100.00
Day 1	2.045	29.91	99.71
Day 2	2.040	29.83	99.46
Day 3	2.034	29.75	99.17
Day 4	2.028	29.66	98.88
Day 5	2.022	29.57	98.58
Day 6	2.016	29.48	98.29
Day 7	2.010	29.39	98.00

- *Descriptive Statistical Summary of Forced Degradation Data*

Table 10 sets out the mean, standard deviation and spread of degradation values for each drug across the five stress tests. Selegiline and Mirtazapine post the lowest averages and the tightest spreads, confirming that their resistance was not a one-off result under a single stress but held reasonably steady across all five. Amitriptyline sits at the other extreme in terms of variability – its degradation ranged from as little as 8.21% under alkali to as much as 70.89% under heat, a spread of over 60 percentage points that reflects how strongly its stability depends on exactly which stress it meets.

Table 10 Descriptive Statistics of Percentage Degradation Across the Five Stress Conditions

Drug	Mean % Degradation	SD	Range (%)
Fluoxetine	44.51	21.16	15.82 – 69.02
Duloxetine	44.52	29.23	11.30 – 78.26
Amitriptyline	36.27	29.61	8.21 – 70.89
Selegiline	30.20	26.28	2.30 – 72.41
Mirtazapine	30.41	16.22	5.48 – 47.95

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug1210

IV. DISCUSSIONS

What stands out most from the degradation data is how little consistency there is between stress conditions for any single drug – stability, it turns out, is not one property but several, and a molecule can be robust against one kind of attack while being vulnerable to another. Amitriptyline illustrates this well: its tricyclic amine structure, lacking a hydrolysable ester or amide bond, shrugged off alkaline attack almost entirely (8.21% loss) yet lost nearly two-thirds of its absorbance under acid and heat (64.18% and 70.89%), which points to the dibenzocycloheptene ring and its exocyclic double bond as the more vulnerable feature rather than any linkage susceptible to simple base hydrolysis. Selegiline tells the opposite story in places – its propargylamine group left it the most heat- and light-resistant drug in the panel and gave it the lowest overall mean degradation, and yet that same secondary amine appears to be exactly what alkali attacks, since Selegiline lost more under base (72.41%) than any other drug tested. Duloxetine, built around a naphthyloxy-thiophene chromophore, was consistently the drug most affected by heat and light (78.26% and 37.39%), suggesting a thermolabile and photolabile ether linkage or aromatic system as the likely weak point.

Pooling the five stress results into a single average degradation figure per drug puts Selegiline (30.20%) and Mirtazapine (30.41%) ahead of the pack, Amitriptyline in the middle (36.27%), and Fluoxetine (44.51%) and Duloxetine (44.52%) trailing. That same ordering – Selegiline best, Duloxetine worst – reappeared almost exactly in the separate seven-day ambient stability run, even though the scale of change was obviously much smaller day-to-day (1.64–5.59% over a week) than under forced stress (up to 78.26% within hours). Two independent experiments landing on the same relative ranking is a reasonable indication that what is being measured is a genuine, structure-linked difference in chemical robustness rather than noise or a quirk of one particular experiment, and it lends some weight to using a short forced-degradation screen as an early pointer toward how a drug will actually hold up on the shelf.

On the analytical side, R^2 values of 1.0000 across all five calibration curves show the method was precise enough to pick up the comparatively subtle day-to-day shifts seen in the stability arm, while still handling the much larger swings produced by forced stress without any change in approach. Combined with its low reagent cost, quick turnaround and minimal sample handling, that dual sensitivity is a reasonable case for keeping UV spectrophotometry as a first-pass, stability-indicating option for comparative work of this kind, especially where chromatographic equipment is not close at hand. The obvious caveat is that UV absorbance is a blunt instrument – it cannot tell the parent drug apart from a degradation product that happens to absorb at a similar wavelength, so the specific breakdown pathways implied here would still need HPLC or LC-MS confirmation before anyone treats them as established.

V. CONCLUSION

Running five marketed antidepressant tablets through the same forced-degradation and short-term stability protocol, using UV-Visible spectrophotometry throughout, showed that no drug was uniformly the most or least stable – vulnerability shifted with the type of stress, with Amitriptyline hit hardest by acid, Selegiline by alkali, Fluoxetine by oxidation, and Duloxetine by both heat and light. Once the five stress results were averaged and checked against seven days of ambient storage data, a consistent picture emerged: Selegiline Hydrochloride and Mirtazapine stood out as the sturdiest of the five, and Duloxetine Hydrochloride as the least so. The agreement between the forced-stress ranking and the real-time storage ranking is a useful finding in its own right, and UV-Visible spectrophotometry – simple, inexpensive and sensitive enough to catch both large and small changes – held up well as the tool for making that comparison, supporting its wider use for preliminary stability screening of antidepressant tablet formulations.

ACKNOWLEDGEMENT

The authors thank the Department of Pharmaceutical Chemistry, SSM College of Pharmacy, Bhavani, Erode, for the laboratory facilities extended for this work.

REFERENCES

[1]. World Health Organization. Depressive disorder (depression) - Key facts. Geneva: WHO; 2023.
[2]. International Council for Harmonisation (ICH). ICH Q1A(R2): Stability Testing of New Drug Substances and Products. Geneva: ICH; 2003.
[3]. International Council for Harmonisation (ICH). ICH Q1B: Photostability Testing of New Drug Substances and Products. Geneva: ICH; 1996.
[4]. International Council for Harmonisation (ICH). ICH Q2(R1): Validation of Analytical Procedures - Text and Methodology. Geneva: ICH; 2005.
[5]. Indian Pharmacopoeia. Indian Pharmacopoeia Commission, Ghaziabad, latest edition.
[6]. British Pharmacopoeia. The Stationery Office, London, latest edition.
[7]. United States Pharmacopeia-National Formulary (USP-NF). United States Pharmacopeial Convention, Rockville, latest edition.
[8]. US Food and Drug Administration. Guidance for Industry: Q1A(R2) Stability Testing of New Drug Substances and Products. Rockville: USFDA/CDER; 2003.
[9]. Central Drugs Standard Control Organisation (CDSCO). Guidelines on Stability Testing of Pharmaceutical Products. New Delhi: Ministry of Health and Family Welfare, Government of India.
[10]. Beckett AH, Stenlake JB. Practical Pharmaceutical Chemistry, Part II. 4th ed. New Delhi: CBS Publishers.
[11]. Skoog DA, Holler FJ, Crouch SR. Principles of Instrumental Analysis. 7th ed. Boston: Cengage Learning.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26aug1210

[12]. Sethi PD. Quantitative Analysis of Drugs in Pharmaceutical Formulations. 3rd ed. New Delhi: CBS Publishers.
[13]. Connors KA, Amidon GL, Stella VJ. Chemical Stability of Pharmaceuticals: A Handbook for Pharmacists. 2nd ed. New York: Wiley.
[14]. Chatwal GR, Anand SK. Instrumental Methods of Chemical Analysis. 5th ed. Mumbai: Himalaya Publishing House.
[15]. Sharma YR. Elementary Organic Spectroscopy: Principles and Chemical Applications. 4th ed. New Delhi: S. Chand Publishing.
[16]. Allen LV, Adejare A, editors. Remington: The Science and Practice of Pharmacy. 23rd ed. Philadelphia: Lippincott Williams & Wilkins.
[17]. Tripathi KD. Essentials of Medical Pharmacology. 8th ed. New Delhi: Jaypee Brothers Medical Publishers.
[18]. Sweetman SC, editor. Martindale: The Complete Drug Reference. 39th ed. London: Pharmaceutical Press.