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Analytical Techniques for The Study of Newly-Approved Anticancer Drugs

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ABSTRACT
The development of innovative chemotherapeutic medications is essential for both patient care and pharmaceutical advancement and research. One approach to achieving this crucial objective is to repurpose current medications that could have unforeseen effects as possible candidates. A thorough analysis of existing anticancer treatments might provide valuable data on patterns in their development, which could help with the methodical search for new anticancer treatments. Analysis of cytotoxic medications is a topic that affects all pharmaceutical disciplines, from the development of novel compounds through patient dosage. The use of techniques including HPLC, ELISA, and LC-MS to analyse new anticancer drugs in different matrices (pharmaceutical dosage forms and biological samples) is reviewed in this study. We anticipate that our review will give a summary of the documented analytical techniques used to determine the recently licensed anticancer medications.
Keywords: *Analytical techniques, Anticancer drugs, Food and Drug Administration, HPLC, ELISA, LC-MS*

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INTRODUCTION

Cancer continues to be the primary cause for mortality worldwide. Current non-operative cancer therapy approaches, such as chemotherapy and radiation, have faced significant difficulties for years due to the low life expectancy, complications, relapse, and poor prognosis. Unfortunately, because of medication tolerance, potential cytotoxicity, and other long-term adverse effects of such therapies, the life expectancy of people with cancer, especially those in late stages, continues to be incredibly low. This has inspired researchers to look for more efficient methods and develop new anticancer medications. The introduction of medicines with a unique mode of action has resulted in the most significant clinical breakthroughs in chemotherapeutic medications. Anthracyclines or taxanes are two new kinds of cytotoxic drugs that significantly improved clinical outcomes in a variety of tumour forms. Monoclonal antibodies are new anticancer treatments, but proper trials are still needed to determine if they are effective. In addition, contradictory to all predictions, their safety appears to be poor.

Generally, randomized controlled studies with a main outcome, such as survival rates, were required to show good outcomes in order to receive FDA approval for novel anticancer treatments. Over the past ten years, the FDA has approved an increasingly greater number of chemotherapeutic agents. It has raised the basic question as to whether the FDA approves treatments that are transformative or treatments that only have a very little advantage over already available medications. The FDA authorized 18 new cancer treatments in 2020, and despite COVID-19's sustained effects, 15 new anti-cancer agents were received approval in 2021.

Some of the recently approved anticancer drugs

The FDA has authorized several medications and increased their list of acceptable uses for treating various tumors and undesirable side effects during the last year. Following is a list of the newly-approved drugs and expedited approvals (Table 1).

Table 1: List of newly approved anticancer drugs

Drug	Category	Type of cancer	Year of approval
Abemaciclib	CDK 4/6 inhibitor	Breast cancer	2021
Alpelisib	Pi3K inhibitors.	*PIK3CA*-mutated cancer	2019
Asciminib	Tyrosine kinase inhibitor	Philadelphia chromosome-positive chronic myeloid leukemia (Ph+ CML)	2021
Atezolizumab	Monoclonal antibodies	NSCLC	2021
Avapritinib	Selective tyrosine kinase inhibitor	Advanced systemic mastocytosis	2021
Axicabtagene ciloleucel	CAR-T Cell Therapies.	Large B-cell lymphoma	2022
Brexucabtagene autoleucel	(CAR) T-cell therapy	B-cell precursor acute lymphoblastic leukemia	2021
Cabozantinib	TKI	Metastatic differentiated thyroid cancer	2021
Carfilzomib	Proteasome inhibitors	Relapsed or refractory multiple myeloma	2020
Cetuximab	Epidermal Growth Factor Receptor (EGFR) Inhibitor	EGFR-expressing colorectal cancer (mCRC) or squamous cell carcinoma of the head and neck	2021
ciltacabtagene autoleucel	CAR-T Cell Therapies	Relapsed or refractory multiple myeloma	2022
Dostarlimab	Monoclonal antibodies	Mismatch repair deficient (dMMR) recurrent or advanced solid tumors	2021
durvalumab	Monoclonal antibodies	Advanced or metastatic biliary tract cancer	2022
Enfortumab vedotin	Nectin-4-directed antibody and microtubule inhibitor conjugate	Pretreated Locally Advanced or Metastatic Urothelial Cancer	2021
Infigratinib	Kinase inhibitors.	Metastatic cholangiocarcinoma	2021
Ivosidenib	IDH1 inhibitors	(IDH1) mutated cholangiocarcinoma	2021
Lenvatinib	TKI	Advanced renal cell carcinoma (RCC).	2021
Lutetium vipivotide tetraxetan	Radioligand therapeutic agent.	Metastatic castration-resistant prostate cancer	2022
Mobocertinib	EGFR tyrosine kinase inhibitor	Metastatic non-small cell lung cancer	2021
Nivolumab	Monoclonal antibodies	Resectable NSCLC	2022
Nivolumab/relatlimab	Monoclonal antibodies	Unresectable or metastatic melanoma	2022
Olaparib	PARP Inhibitors.	Deleterious or suspected deleterious germline BRCA-mutated (gBRCAm) human epidermal growth factor receptor 2 (HER2)-negative high-risk early breast cancer	2022
Pacritinib	Kinase inhibitor	High-risk primary or secondary myelofibrosis	2022
Pafolacianine	-	Ovarian cancer	2021
Pembrolizumab	Monoclonal antibodies	Advanced endometrial carcinoma that is microsatellite instability-high (MSI-H) or mismatch repair deficient (dMMR)	2022
Piflufolastat f-18	PSMA PET imaging agent	Prostate cancer	2021
Rituximab	Monoclonal Antibodies	Large B-cell lymphoma (DLBCL), Burkitt lymphoma (BL), Burkitt-like lymphoma (BLL), or mature B-cell acute leukemia (B-AL).	2021
Sotorasib	RAS GTPase family inhibitor	Metastatic non-small cell lung cancer (NSCLC)	2021
Tebentafusp	Bispecific gp100 peptide-HLA-directed CD3 T cell engager	Metastatic uveal melanoma	2022
Tisotumab vedotin	Tissue factor-directed antibody and microtubule inhibitor conjugate	Metastatic cervical cancer	2021
Trastuzumab deruxtecan	Monoclonal antibody	HER2-low breast cancer	2022
Zanubrutinib	TKI	Waldenström's macroglobulinemia	2021

Analytical techniques for recently approved anticancer drugs

Table 2 summarizes the different analytical techniques included in this study.

Table 2: Summary of the different analytical techniques included in this study

Drug	Technique	Column Used	Mobile Phase	Conc. Range	Sample	References
Abemaciclib	UHPLC–MS/MS	Kinetex C_{18} column (150 × 2.1 mm ID, 2.6 µm)	A- 10 mM Am-HCO_3 in water B- MeOH: water (9:1)	1–600 ng/mL	Human and mouse plasma	[1]
	LC-MS/MS	C_{18} column	A- 10 mM Am-HCO_3 in water B- Water: MeOH (1:9)	2 to 200 ng/mL	Human and mouse sample	[2]
		Kinetex™ F_5 column	A- 5 mM Am. formate with 0.1% FA B- ACN: MeOH (1:1)	0.2-500 nM	human plasma, brain tumor, and cerebrospinal fluid samples	[3]
	RP-HPLC	Zorbax Eclipse C_{18} column	10 mM Am. acetate (pH 5): ACN	0.10–10 µg/ml	Rat plasma	[4]
	LC-MS/MS	Gemini-NX C_{18}, 5 µm, 4.6 × 50 mm	A-100:1: 0.1 water/1 M Am acetate/AmOH B- 10:90:0.1 isopropanol/NOWPak® MeOH/AmOH C- 10:90:0.1 isopropanol/NOWPak® ACN/AmOH	1 ng/ml to 500 ng/ml	Human plasma	[5]
Alpelisib	HPLC-FLD	CAPCELL PAK C_{18} MGIII HPLC column (250 × 4.6 mm, 5 µm)	Potassium phosphate buffer (10 mM, pH 6.6): ACN (59:41)	1–1,000 ng/mL	Rat plasma	[6]
	UPLC-MS	Acquity UPLC BEH C_{18}	ACN and water	1–5,000 ng/ml	Rat plasma	[7]
	LC-MS/MS	Zorbax C_{18} (50 × 4.6 mm, 5 µ)	0.1% FA: ACN (10:90)	145 and 5,800 ng/ml	Human plasma	[8]
Atezolizumab	UV/Vis spectroscopy	Beckman Coulter DU® 730 Life Science UV/Vis Spectrofotometer	-	0.10 to 1.50 mg/mL	Pharmaceutical dosage form	[9]
Avapritinib	LC-MS/MS	X-Bridge phenyl (1504.6mm, 3.5µm) column	0.1% OPA: ACN (50: 50)	5-100 ng/ml	Rat plasma	[10]
	RP-HPLC	n C_{18} column (Xterra R_{18} 150*4.6, 5µm)	0.1%v/v FA in water: ACN (40:60)	50-150µg/ml	-	[11]
	UPLC-MS/MS	UPLC BEH C_{18} column (2.1 mm x 50 mm, 1.7 µm)	0.1% FA in water and ACN	2–4000 ng/mL	Rat plasma	[12]
Cabozantinib	Green RP-HPTLC and green NP-HPTLC techniques	RP-18 silica gel 60 F254S HPTLC plates	ACN: H_2O (85:15)	10–1000 ng $band^{-1}$	Pharmaceutical formulation	[13]
		NP-18 silica gel 60 F254S HPTLC plates	Ethyl acetate: EthOH (97.5:2.5)	50–600 ng $band^{-1}$		
	LC-MS/MS	Waters Atlantics C_{18} column (2.1×150 mm, 3 µm)	ACN: 10 mM Am. acetate solution containing 0.1% FA (78:22)	0.500-5000 ng/mL	Rat plasma	[14]

	RP-HPLC	C_{18} column (250 mm × 4.6 mm, 5 µm)	0.1% FA: ACN: MeOH (35:33:32)	100- 500 µg/mL	Pharmaceutical formulation	[15]
	Micellar liquid chromatography (MLC) method	Kinetex C_{18} 100 A˚ column	ACN: CTAB: tris buffer (pH 8.5) (40:50:10)	20 to 700 ng/mL	Human serum samples	[16]
Carfilzomib	RP-HPLC	YMC-Pack ODS-A (150 mm x 4.6 mm, 3µm)	pH 5.5 potassium di-hydrogen phosphate buffer, ACN and MeOH	0.325 - 2.259 µg/mL	-	[17]
	UV spectrophotometric	-	MeOH	4-16 µg/ml	-	[18]
Cetuximab	LC-HRMS	XB-C_{18} chromatographic column (100 · 2.1 mm, 2.6 mm)	A- H_2O: FA (0.1%) B- ACN: FA (0.1%)	5 to 150 mcg/mL	Human plasma	[19]
	RP-HPLC	Agilent Zorbax® 300SB-C8 (150 mm × 4.6 mm, 5 µm)	0.1% TFA: ACN: isopropanol	75-300 µg mL^{-1}	Immunoliposomes	[20]
	RP-HPLC	C_{18} column	TFA: ACN	3–250 µg/mL	Pharmaceutical formulation	[21]
Ivosidenib	LC-ESI-MS/MS	Atlantis dC_{18} column	0.2 % FA in water: ACN (25:75)	1.10-3293 ng/mL	Mice plasma	[22]
	UPLC-MS/MS	C_{18} column	A- FA: water B- ACN	2–2,000 ng/mL	Rat plasma	[23]
	HPLC	X- Terra Phenyl column (150 × 4.6 mm, 5 µm)	10 mM Am. acetate (pH 4.5): ACN	0.50–12.5 µg/ml	Mouse plasma	[24]
Lenvatinib	UV spectroscopy	HiQSil 4.6 X 250 mm, 5µ, C8 column	MeOH: Am. acetate buffer 30:70	10-40 µg/mL	Bulk formulations	[25]
Nivolumab	Far-UV CD, IT-FS, DLS, SE/UHPLC(UV)-MS, and ELISA	SEC column (300 A, 2.7 µm, 4.6 × 300mm)	150 mM of phosphate buffer pH 7.0	0.5-100 ng/mL	Pharmaceutical formulation	[26]
	RP-UHPLC/UV-(HESI/Orbitrap™)MS	MAbPac™ RP column, 4 µm, 2.1 mm × 50 mm	Water and ACN and TFA or FA	4–45 µg/mL and 1–45 µg/mL for the UV and (HESI/Orbitrap™) MS	Pharmaceutical formulations	[27]
Olaparib	HPLC-ESI–MS/MS	Phenomenex Gemini C18 column	ACN and Am. formate 10 mM	Cell culture-0.1–10ng/mL Nuclei-0.5–10ng/mL Plasma & urine- 0.5–100ng/mL Tissue- 0–500ng/mL	Plasma, urine and tissue samples	[28]
	RP-HPLC	Waters symmetry C18 (150 x 4.6 mm, 5 µm)	Am. acetate buffer: MeOH (50:50)	80 µg/mL to 120 µg/mL	Tablet formulation	[29]
Pembrolizumab	LC-MS/HRMS and ELISA	Biozen Peptide-PS-C_{18} (100 × 2.1 mm, 1.6 µm)	A- Water in FA B- ACN in FA	1–100 µg/mL	Human plasma	[30]
	LC-MS/MS method and ELISA	XB C18 Kinetex, (2.6 µm, 2.1 mm × 50 mm)	98:2 H_2O: ACN + 0.1% FA	1 to 200 µg/mL	Human serum sample	[31]

Rituximab	Size exclusion high performance liquid chromatography (SE-HPLC), RP-HPLC, quantitative gel electrophoresis by TapeStation, receptor binding assay and dynamic light scattering (DLS).	**SE-HPLC:** TSK gel G3000SWXL (7.8 × 300 mm), 5 µm	Phosphate buffer (0.2 M, pH 6.7 ± 0.05), 0.25 M KCl	0.5–10 mg mL^{-1}	-	[32]
		RP-HPLC: 250 × 4.6 mm, 5 µm C8 column (Zorbax)	A-0.1% TFA in water B-0.1% TFA in ACN.	0.5–10 mg mL^{-1}		
Sotorasib	LC-MS	Acquity UPLC® BEH C18 column	MeOH: 0.1% FA in water	2–2,000 ng/ml	Mouse plasma and organ homogenates	[33]
	HPLC-MS/MS	Waters XBrige C_{18} column (50 mm × 2.1 mm, 3.5 µm	0.1% FA	0.2 to 5,000 ng/ml	Rat plasma	[34]
Zanubrurinib	LC-MS/MS	-	-	0.1–100 ng/mL	Rat plasma	[35]
	RP-HPLC	C18 column (250 × 4.6 mm, 5-µm)	ACN: 0.1% TEA(65:35)	-	-	[36]
	UPLC–MS/MS	Acquity BEH C_{18} column (2.1 mm × 50 mm, 1.7 µm)	A- 0.1% FA B- ACN	1.0–1,000 ng/ml	Beagle dog plasma	[37]

MeOH: Methanol; **ACN:** Acetonitrile; **FA:** Formic acid; **TFA:** Trifluoroacetic acid; **CTAB:** cetyltrimethylammonium bromide; **TEA:** Triethylamine; **EthOH:** Ethanol

Abemaciclib

Abemaciclib was issued FDA approval in 2021 for use in combination with hormonal therapy (toremifene or an aromatase antagonist) as an adjunctive therapy for adult individuals with newly diagnosed, node-positive, HR+ breast cancer who are at severe risk of relapse and who have a Ki-67 score exceeding 20%. Three major intermediates are generated by the complete metabolism of abemaciclib by CYP3A4 in humans: N-desethylabemaciclib (M2), hydroxyabemaciclib (M20), and hydroxy-N-desethylabemaciclib (M18). These compounds were substantially more prevalent in plasma circulation than the parent medication and shown equivalent efficacy. Therefore, M2, M20, as well as M18 could be involved in how abemaciclib works clinically. In order to facilitate more clinical or preclinical research on this medicine, a UHPLC-MS/MS technique for the concurrent measurement of abemaciclib as well as its bioactive compounds in mice and human plasma was designed and validated. Inter-species discrepancies across mice and human samples were found, particularly during the synthesis of M20, wherein only mouse plasma included isomers of this chemical. In another investigation, the medication was quantified using LC-MS/MS, and stability tests revealed that it remained stable in all examined tissues (brain, liver, kidney, spleen, and small intestine cell lysates). In another investigation, the medication was quantified using LC-MS/MS, and stability tests revealed that it remained stable in all examined tissues (brain, liver, kidney, spleen, and small intestine cell lysate. The validated technique was also effectively used in a phase 0/2 clinical study to determine the degree of abemaciclib's permeation into the CNS. Comparable to this, the establishment and validation of bioanalytical techniques such as RP-HPLC and green capillary electrophoresis for measuring abemaciclib were carried out in accordance with the USFDA criteria. When given orally to individuals suffering late-stage cancer, the efficacy and tolerance of abemaciclib were evaluated using LC-MS/MS. A sample reanalysis pass percentage of more than 95% in clinical investigations showed that the approach performed consistently over time. Abemaciclib's linearity was established through LC-MS across 40–800 ng/mL and 10–200 ng/mL for M2 and M20, respectively [38].

Alpelisib

Alpelisib received approved from the FDA in 2022, for treatment of children (above 2 years) and adults who have significant PROS (PIK3CA-related overgrowth spectrum) symptoms and need systemic treatment. For the detection of alpelisib in mouse plasma, an efficient bioanalytical technique called HPLC with a fluorescence detector was established. Based on FDA guidelines, this unique technique was validated, and the variables were all within specified ranges. Alpelisib reported to remain stable for 24 hours in plasma, urine, and buffers having pH > 4.0, and for up to 4 hours in simulated gastrointestinal fluid and buffers having a pH of 1.2. Ketoconazole significantly raised the circulating levels of alpelisib and

altered its pharmacokinetics better than itraconazole did, according to research on drug-drug interactions. The plasma concentrations of alpelisib were detected using the UPLC-MS method. In a different investigation, the LC-MS/MS method was designed to quantify the amount of the alpelisib in plasma samples. It was shown to be very stable in a variety of analytical settings [39].

Atezolizumab

In 2021, the FDA authorized atezolizumab for use in patients suffering from moderate to advanced NSCLC whose tumours exhibit PD-L1 expression on 1% of cancerous cells, as adjunctive therapy after excision and platinum-based chemotherapy. The ability to quantify the presence of atezolizumab in therapeutic drugs, market samples, different dosage forms, and mice/human blood/plasma has been demonstrated to be possible using UV/Vis spectroscopy [40].

Avapritinib

Avapritinib has been approved by FDA for use in adults with late-stage systemic mastocytosis, such as those with aggressive systemic mastocytosis, systemic mastocytosis with an associated hematological neoplasm. An analytical technique (RP-HPLC) has been devised for the quantification of avapritinib. The permissible range was fulfilled by all validation criteria. For avapritinib, the test procedures showed linearity between 50 and 150 g/ml. The drug was measured in rat plasma after being given orally in a single dosage of 30 mg/kg utilizing bioanalytical LC-MS/MS and UPLC-MS/MS and was discovered to be stable across the freeze-thaw, auto sampler, bench top, and long-term stability assays.

Cabozantinib

Cabozantinib (CZN) has been approved by FDA for use in adult and pediatric patients (above 12 years) who have differentiated thyroid carcinoma (DTC) that is regionally progressive or metastatic, has worsened after prior VEGFR-targeted treatment, and who are contraindicated for or intolerant to radioiodine. Comparing green RP-HPTLC and green NP-HPTLC methods for CZN estimation, it was shown that RP-HPTLC outperformed the NP-HPTLC. As compared to NP-HPTLC-densitometry, the RP-HPTLC approach demonstrated great sensitivity for the measurement of CZN. The CZN concentration of commercially available capsules and tablets was determined by RP-HPTLC-densitometry to be 98.77% and 101.17%, correspondingly. Using NP-HPTLC it, was discovered to be 94.25% and 96.12%, correspondingly. In pharmacokinetic research involving Sprague-Dawley rats, LC-MS/MS was effectively used for the concurrent quantification of cabozantinib N-oxide (CBN), a breakdown product of CZN. CBZ (1, 5 and 12.6 mg/kg) demonstrated dosage proportionality following oral treatment, however its metabolite CBN had blatantly nonlinear elimination pattern, exhibiting exposure greater than dose proportionally. Another research using RP-HPLC confirmed the linearity of CZN between 100–500 g/mL with correlation values of 0.990. CZN's % recoveries were discovered to be between 99.59 and 99.96%. To show the method's specificity, stress tests were conducted. The established technique was able to separate possible degradants from CZN. CZN, a chemotherapeutic medication, and its main metabolites may be quantified in serum samples from humans using a micellar liquid chromatography approach that has been shown to be very sensitive and inexpensive [41].

Carfilzomib

Among adult individuals who have undergone multiple lines of chemotherapy and have relapsed or become resistant to treatment for multiple myeloma, the FDA has authorized the use of carfilzomib plus daratumumab in conjunction with dexamethasone. 30 diastereomers of the active component in carfilzomib (CFZ) and 6 process-related impurities were determined and separated using a unique RP-HPLC technology. The suggested approach offers excellent resolution among drug, its diastereomers and impurities. Carfilzomib's maximum absorbance was determined to be 203 nm using the UV spectrophotometric technique. The linearity was established to possess an excellent correlation value (R^2 = 0.9952) across 4-16 μg/ml. The accuracy ranged between 99.4-101.2%, and the LOD and LOQ were 0.00156 μg/ml and 0.00472 μg/ml, correspondingly.

Cetuximab

A flexible, efficient, and high-throughput sample processing technique that relies on IgG capturing and metabolism by trypsin, on-line solid-phase extraction cleaning, and LC-high resolution mass spectrometry (LC-HRMS) was utilized to analyze cetuximab in plasma samples. The optimized procedure had excellent analytical efficiency and showed linearity between 5 and 150 mcg/mL. In another study utilizing RP-HPLC in conjunction with a PDA detector, cetuximab was measured. The devised technique was linear across the concentrations between 75–300 μg/mL. The quantitative technique's applicability was evaluated through the production of PTX-coated immunoliposomes coupled with CTX. Present-day developments in drug delivery technologies that use nanotechnology have made it possible to combine many medications into a single Nano carrier and have improved the recommended regimen therapeutically. For the concurrent measurement of CTX and Alpha-cyano-4-hydroxycinnamic acid (CHC), RP-HPLC combined with fluorescence detector was established (Ferreira et al., 2020). The proposed technique was also effectively

applied for the first time to measure the CHC and CTX contents in nanomaterials made of poly (lactic-co-glycolic acid). Additionally, the specific and quantitative assessment has been made possible by using fluorescence detector for this reason which, reduces the LOQ and LOD values often achieved with UV detector.

Ivosidenib

Ivosidenib was given FDA approval in 2021 for treating adult patients having isocitrate dehydrogenase 1 (IDH1) mutant cholangiocarcinomas in hepatic cells that are unresectable regionally progressed or metastatic. Ivosidenib concentrations in rat plasma were evaluated using LC-ESI-MS/MS, and it was discovered that the medication remained stable for about 30 days at -80°C, six hours on a bench top, and around three freeze-thaw sessions. A pharmacokinetic investigation on mice has shown the validity of the technique's application. Ivosidenib levels in mice after iv (2 mg/kg) as well as oral (5 mg/kg) treatment were measurable for around 24 and 48 hours, correspondingly. The drug had a bioavailability of 61%. Comparable to this, UPLC-MS/MS was used in a separate investigation by Chen et al. to measure the amount of ivosidenib in rat plasma. With an LLOQ of 2 ng/mL, the calibration curve for IBD was linear across the range of 2-2,000 ng/mL in rat plasma. Furthermore, neither a clear matrix effect nor a carry-over phenomenon were seen. IBD was effectively extracted from plasma using the technology that had been successfully developed. Enasidenib (EDB), ivosidenib (IDB), and vorasidenib (VDB) were simultaneously quantitated in mouse plasma with the help of the HPLC technique [42]. EDB's showed linearity across a range of 0.20–12.5 µg/ml, while IDB and VDB's calibration curves were linear across a range of 0.50–12.5 µg/ml (r^2 = 0.998 for all the samples).

Lenvatinib

In 2021, the FDA authorized the use of lenvatinib (LNV) and pembrolizumab (PEB) together as the first-line therapy for individuals with late-stage renal cell carcinoma (RCC). Five LNV mesylate solid-state derivatives, involving two polymorphs (LEM-A, LEM-C) and three pseudo polymorphs (a hydrate, LEM-H, and two iso-structural solvates, LEM-H-EA and LEM-H-THF) were synthesized and analyzed through diverse techniques. Thermal analysis and XRD were used to describe the hydrate and iso-structural solvates. LEM-A, LEM-C, and LEM-H's thermostability and solubility, as well as the corresponding molecular configuration, associated inter- and intramolecular linkages, and packing patterns, were all evaluated. LNV has been verified for use with the UV spectrophotometry, RP-HPLC technique across the linearity between 10–40 µg/mL (r^2=0.9992).

Nivolumab

Nivolumab (NVM) has been licensed by the U.S. Food and Drug Administration for use in patients with urothelial carcinoma (UC) who pose a high chance of relapse following radical excision. A variety of analytical methods, including DLS, Far-UV CD, IT-FS, and ELISA, SE/UHPLC(UV)-MS, were used to characterize the functional and physicochemical properties of Nivolumab under diverse stress conditions. The findings indicate that the stress condition that had the greatest influence on the samples was light exposure, which revealed the formation of artificial dimers and a distinct isoform composition. Nivolumab also showed stability for about an hour when kept at 60 degrees Celsius. Each of the stressed sample was reported to be stable in terms of functioning, with the exception of those that were exposed to light, agitating, and, to a smaller degree, FTC 5 and Nacl stressors. NVM was quantified using an RP-UHPLC/UV-(HESI/Orbitrap ™) MS approach, and the outcomes from the two separate detectors (UV and MS) were contrasted. To determine if Nivolumab experiences structural changes under stress, accelerated degradation was performed. Since alterations of this kind generate new isoforms that cannot be isolated or identified by the UV signal, structural alterations were discovered by analyzing the MS isoform profile.

Olaparib

Olaparib was given FDA approval in 2022 as an adjunctive treatment in individuals having elevated chance of early-stage breast cancer who have severe or supposed severe germline BRCA-mutated (HER2)-negative tumours. Olaparib requires a concomitant diagnostic that has been authorized by the FDA before a patient may begin treatment. A quick and reliable HPLC-ESI-MS/MS approach was developed to quickly and accurately measure the quantity of olaparib in ferritin nanostructures. This technique allowed for the production of cellular components, various tissues, plasma, and urine samples, which were then verified to determine how the medication was distributed inside cell compartments after being delivered through nanotechnology. This approach enables the measurement of olaparib inside the linearity ranges of 0.1–10ng/mL in cell culture media and cell cytosol, 0.5–10ng/mL in nucleus, 0.5–100ng/mL in plasma and urine samples, and 10–500ng/mL in tissue samples (kidney and liver). When Olaparib was quantified employing RP-HPLC by Chaudhary et al., the correlation coefficient of 0.998 indicated that the developed technique is linear across 80 µg/mL to 120 µg/mL of concentration. Under all stress settings, with the exception of acidic environments, olaparib was shown to be extremely stable according to degradation experiments.

Pembrolizumab

For those with late-stage endometrial cancer that has microsatellite instability-high (MSI-H) or mismatch repair deficiency, the FDA authorized pembrolizumab as a single treatment in 2022. For the analytical measurement of PEM in plasma samples, a completely designed, optimized, and validated LC-MS/HRMS technique has been used. An internal ELISA with a linear concentration between 2.5 to 50 µg/mL was established parallelly. With the use of Bland-Altman charting and Passing-Bablok regression analysis, PEM analyzed using the two techniques was compared. It is more suitable to utilize the LC-MS/HRMS technique for PK/PD investigations, clinical studies, or TDM studies. Li et al. gave crucial structural insights that made it easier to construct the PEM crystalline suspension. Utilizing magic angle spinning (MAS) NMR spectrometry, research characterized the PEM microcrystalline suspension and assessed the effects of temperature and dehydration on its structure, characteristics, and stability in the formulation. NVM and PEM levels in blood and CSF were measured utilizing ELISA, and the findings confirmed long-term stability of more than a year. The assay's foundation was the selective entrapment of NVM and PEM by immobilized PD-1, followed by an enzyme-based chemiluminescent detection step using anti-IgG4 and horse radish peroxidase.

Rituximab

For children (6 months to 18 years old) having critical stage CD20-positive diffuse large B-cell lymphoma, Burkitt lymphoma, or mature B-cell acute leukemia or Burkitt-like lymphoma, the FDA authorized rituximab in conjunction with chemotherapy in 2021. Rituximab (RTM) and eculizumab (ECZ) were simultaneously quantified using an LC-MS/MS approach, and this technique was contrasted against commercially available ELISA kits. A comparative study of the LC-MS/MS approach with ELISA revealed low bias when Lisa Tracker® kit (4%) was used, but considerable bias when the Promonitor® assay (69%) was used for RTM. Calibration curves exhibited linearity between 1 to 200 µg/mL. Using a variety of bioanalytical techniques (Table 2), Trabik et al. examined the impact of various stress conditions on the trend and reactions of RTM degradation. The receptor binding experiment, which also supported the SE-HPLC findings, indicated that degradants did not affect the binding affinities of the two components. Despite its potential to change the degradation pattern, glycoengineering did not show much of an influence on the level of degradation. Observations from gel electrophoresis, revealing reducible covalent bonds as the basis for aggregation building, were also verified. The RP-HPLC findings revealed two oxidized variants of RTX and OBZ due to extensive oxidation, with approximately the same percentage of degradation. .

Ruxolitinib

Following the ineffectiveness of one or two lines of standard chemotherapy in adults and children above 12 years, ruxolitinib (RXB) was authorized by the FDA for the treatment of chronic graft-versus-host disease (cGVHD). A cutting-edge and environmentally friendly nano sensor was designed for detecting RXB. For pharmaceutical analysis, a renewable material made from discarded sponges was employed. With no regeneration, the sensor's surface displayed excellent performance for about 4 days.

Sotorasib

Acquity UPLC® BEH C18 column has been used to effectively design and validate a bioanalytical LC-MS technique for quantifying sotorasib (STR) in plasma and tissue samples. The technique facilitated a pharmacokinetic study and did not exhibit a matrix effect or considerable extraction loss. As a result, the technique is applicable for preclinical research on STR [43]. In a different investigation, STR was quantified utilizing HPLC-MS/MS, and a transverse and longitudinal PM was used to compare PK by applying Pearson's analysis and a partial least squares regression. Six and nine assessed factors were substantially linked with the AUC and C_{max} of STR, correspondingly, adopting two-stage PLS and OPLS-DA analyses, suggesting that these prospective biomarkers might anticipate drug concentration or toxicity.

Zanubrutinib

A thorough QT (TQT) research used concentration-QTc (C-QTc) model as the major assay to assess the impact of zanubrutinib (ZBT) on ECG parameters. The QTc interval was not lengthened by a single 160-mg or 480-mg dosage of ZBT, nor were there any major medically significant changes to the ECG parameters. Therefore, it is doubtful that ZBT at the standard dose of 160 mg t.i.d or 320 mg o.d. will affect patients' cardiac repolarization in a way that is clinically significant. In a trial, ZBT was administered intragastrically to rats at a dose of 30 mg/kg to ascertain its pharmacokinetic properties. The technique was examined and shown linearity between 0.1–100 ng/mL range [44]. Following research on ZBT degradation by TQMS, ZBT quantification was performed utilizing RP-HPLC. A set of four degradation products, namely DP1 in acid and base degradation, DP2 in oxidative stress, and DP3, DP4 in reductive stress conditions, were identified. Utilizing UPLC-MS/MS, ZBT pharmacokinetic investigations were carried out in plasma samples from beagle dogs after oral dosing. The calibration graph shown excellent linearity (r^2 = 0.9998) between 1.0-1,000 ng/ml. Additionally, the recoveries in the plasma varied between 90.12 through 93.53% (RSD 1.67-6.42%), while the intra-day and inter-day precision equaled 5.88%. [45]

FUTURE PROSPECTS

Because each of the aforementioned approaches has benefits and drawbacks, it is important to choose the optimal technique to address the problem at hand. Preferably, multiple complementary strategies are employed. Furthermore, proper sample handling is extremely important, particularly when dealing with bioactive molecules, since even the greatest bioanalytical technology will not be able to retrieve analytes that were wasted during sample preparation. For numerous anticancer drugs, LC-MS is currently the technique of first preference for quantitative estimation. Nevertheless, there are still numerous novel advances in this field that may be anticipated, including the establishment of more sensitive and specific mass spectrophotometers, high-throughput assays, and further improvement of the combined LC systems. Expedited MS-based quantifiable isotope measurements might also be used more often. With very little radioactivity, this approach enables the highly sensitive identification of uncommon and long-lived isotopes in extremely tiny sample quantities. It can be a crucial tool when developing phase I pharmacokinetic profiles of novel chemicals and analyzing very tiny quantities of analyte in modest or complicated samples. Due to shorter sample collection times and lower study expenses, simultaneous multi-drug assessment techniques may be helpful for cancer patients receiving multiple-drug regimens. Due to shorter sample collection times and lower study expenses, simultaneous multi-drug assessment techniques may be helpful for cancer patients receiving multiple-drug regimens. Native conditions should be maintained during metallomic experiments since metal-binding to biological systems is sensitive to variations in pH, buffer content, and ionic strength. Latest developments in electrochemistry have seen significant advancements in the establishment of novel and complex techniques for the investigation of anticancer drug-DNA interaction. Novel electrochemical techniques are also being devised, and they might play a significant role in analytical and biological research in the coming years.

CONCLUSION

The number of cancer patients have grown significantly in number during the recent decades. The establishment of trustworthy analytical techniques for evaluating these chemicals became important due to the side effects of cytotoxic drugs to people (including patients and medical workers). Several analytical techniques have been described in the literature during the last few years for chemotherapeutic drug quantification in pharmaceutical dosage forms, biological samples, and experimental materials. We compiled all of the newly authorized anticancer medications in this article, along with the numerous analytical methods used to study them. We thus anticipate that the information gathered in this work will be useful for choosing an analytical approach that is best-suited for estimating anticancer drug molecules, examining their pharmacokinetic profile, and determining their stability under various experimental conditions.

REFERENCES

1. Martínez-Chávez A, Tibben MM, de Jong KA, Rosing H, Schinkel AH, Beijnen JH. (2021). Simultaneous quantification of abemaciclib and its active metabolites in human and mouse plasma by UHPLC–MS/MS. Journal of Pharmaceutical and Biomedical Analysis. 5;203:114225.
2. Martínez-Chávez A, Rosing H, Hillebrand M, Tibben M, Schinkel AH, Beijnen JH. (2019). Development and validation of a bioanalytical method for the quantification of the CDK4/6 inhibitors abemaciclib, palbociclib, and ribociclib in human and mouse matrices using liquid chromatography-tandem mass spectrometry. *Anal Bioanal Chem*. ;411(20):5331-5345. doi:10.1007/s00216-019-01932-w
3. Dhakne P, Sahu AK, Sharma MK, Sengupta P. (2020). Simultaneous quantification of abemaciclib and letrozole in rat plasma: method development, validation and pharmacokinetic application. *Biomed Chromatogr*. 34(6):e4825. doi:10.1002/bmc.4825
4. Wickremsinhe ER, Lee LB. (2021). Quantification of abemaciclib and metabolites: evolution of bioanalytical methods supporting a novel oncolytic agent. *Bioanalysis*. 13(9):711-724. doi:10.4155/bio-2021-0039
5. Mlinarić Z, Turković L, Begović I, Nigović B, Sertić M. (2022). Rapid Capillary Electrophoresis Method for Simultaneous Determination of Abemaciclib, Ribociclib, and Palbociclib in Pharmaceutical Dosage Forms: A Green Approach. *Molecules*. 27(21):7603. Published 2022 Nov 6. doi:10.3390/molecules27217603
6. Margaryan T, Elliott M, Sanai N, Tovmasyan A. (2022). Simultaneous determination of LY3214996, abemaciclib, and M2 and M20 metabolites in human plasma, cerebrospinal fluid, and brain tumor by LC-MS/MS. Journal of Pharmaceutical Analysis. 220.
7. Seo SW, Kim JM, Han DG, Geum D, Yun H, Yoon IS. (2021). A sensitive HPLC-FLD method for the quantification of alpelisib, a novel phosphatidylinositol 3-kinase inhibitor, in rat plasma: Drug metabolism and pharmacokinetic evaluation in vitro and in vivo. *J Chromatogr B Analyt Technol Biomed Life Sci*.;1163:122508. doi:10.1016/j.jchromb.2020.122508
8. Wang Q, Lan X, Zhao Z, et al. (2021). Characterization of Alpelisib in Rat Plasma by a Newly Developed UPLC-MS/MS Method: Application to a Drug-Drug Interaction Study. *Front Pharmacol*. 12:743411. Published 2021 Nov 25. doi:10.3389/fphar.2021.743411

9. Majumder T, Gubbiyappa SK. (2022). Development and validation of LC-MS/MS method for alpelisib quantification in human plasma: Application to pharmacokinetics in healthy rabbits. Journal of Applied Pharmaceutical Science. (Notice: Undefined offset: 3 in/home/japsonli/public_html/abstract. php on line 193).
10. Ekinci M, Akbaba H, Santos-Oliveira R, Ilem-Ozdemir D. (2022). Development and validation of UV/VIS spectroscopy method for determination of atezolizumab in pharmaceutical products. Experimental Biomedical Research. 5(2):175-82.
11. Singh TG, Vadlakonda JB, Gupta VR. (2020). Analytical method development and validation of avapritinib by RP-HPLC method. World Journal of Pharmacy and Pharmaceutical Sciences.9(10):1834-1840
12. Kumari GK, Rambabu K. (2021). Bio-analytical Method Development and Validation for Avapritinib in Rat Plasma by LC-MS/MS. Journal of Pharmaceutical Sciences and Research. 1;13(3):134-7.
13. Xu X, Luo S, Yang Q, Wang Y, Li W, Lin G, Xu RA. (2021). Development and validation of the quantitative determination of avapritinib in rat plasma by a bioanalytical method of UPLC-MS/MS. Arabian Journal of Chemistry. 1;14(6):103152.
14. Alam P, Salem-Bekhit MM, Al-Joufi FA, Alqarni MH, Shakeel F. (2021). Quantitative analysis of cabozantinib in pharmaceutical dosage forms using green RP-HPTLC and green NP-HPTLC methods: A comparative evaluation. Sustainable Chemistry and Pharmacy. 1;21:100413.
15. Ren LJ, Wu HJ, Sun LH, et al. (2018). A sensitive LC-MS/MS method for simultaneous determination of cabozantinib and its metabolite cabozantinib N-oxide in rat plasma and its application in a pharmacokinetic study. *Biomed Chromatogr*. ;32(7):e4227. doi:10.1002/bmc.4227
16. Patel RB, Patel HU, Patel U. (2020). Development and validation of stability indicating rp-hplc method for the estimation of cabozantinib in pharmaceutical dosage form. Int J of Res Anal Rev. 7(4):892-907.
17. Qi X, Zhang S, Yu M, Khan S.(2021). Concurrent detection of cabozantinib as an anticancer agent and its major metabolites in human serum using fluorescence-coupled micellar liquid chromatography. Arabian Journal of Chemistry. 1;14(7):103206.
18. Mu S, Darpo B, Tang Z, Novotny W, Tawashi M, Xue H, Willett M, Lin L, Sahasranaman S, Ou YC. (2020). No QTc prolongation with zanubrutinib: results of concentration-QTc analysis from a thorough QT study in healthy subjects. Clinical and Translational Science. ;13(5):923-31.
19. Retmana IA, Loos NH, Schinkel AH, Beijnen JH, Sparidans RW. (2021). Quantification of KRAS inhibitor sotorasib in mouse plasma and tissue homogenates using liquid chromatography-tandem mass spectrometry. Journal of Chromatography B. 1;1174:122718.
20. Du P, Liu L, Hu T, An Z. (2022). Integrative Analysis of Pharmacokinetic and Metabolomic Profiles for Predicting Metabolic Phenotype and Drug Exposure Caused by Sotorasib in Rats. Frontiers in oncology. :1118.
21. Lu S, Yu K, Wang S, Liu J, Liu S, Hu X, Tang G. (2022). Polymorphs and Pseudopolymorphs of Lenvatinib Mesylate: Crystal Structure, Equilibrium Solubility, and Stability Study. Crystal Growth & Design. 5;22(7):4421-30.
22. Patve RS, Shaikh AR, Inamdar N, Bhise K. (2018). Method development and validation of lenvatinib by HPLC and UV-Spectroscopy. IDMA Bulletin.55(4):39-47.
23. Torrente-López A, Hermosilla J, Pérez-Robles R, Salmerón-García A, Cabeza J, Navas N. (2022b). Combined use of UV and MS data for ICH Stability-Indication Method: Quantification and isoforms identification of intact nivolumab. Microchemical Journal.1;182:107896.
24. Ottria R, Ravelli A, Miceli M, Casati S, Orioli M, Ciuffreda P. (2019). Quantitative Characterization of Olaparib in Nanodelivery System and Target Cell Compartments by LC-MS/MS [published correction appears in Molecules. 2019 May 07;24(9):]. *Molecules*. 2019;24(5):989. Published 2019 Mar 11. doi:10.3390/molecules24050989
25. Konatham Teja Kumar Reddy, & M. Akiful Haque. (2022). Develop and validate a highly sensitive method for the estimation of Molnupiravir in rat plasma by high-performance liquid chromatography-tandem mass spectroscopy and its application to pharmacokinetic studies. Journal of Pharmaceutical Negative Results, 28–34. https://doi.org/10.47750/pnr.2022.13.S01.0
26. Konatham Teja Kumar Reddy, Penke Vijaya Babu, Rajinikanth Sagapola, & Peta Sudhakar. (2022). A Review Of Artificial Intelligence In Treatment Of Covid-19. Journal of Pharmaceutical Negative Results, 254–264. https://doi.org/10.47750/pnr.2022.13.S01.31
27. Konatham Teja Kumar Reddy, Kumaraswamy Gandla, Penke Vijaya Babu, M Vinay Kumar Chakravarthy, Pavuluri Chandrasekhar, & Rajinikanth Sagapola. (2022). A Critical Review On Bioanalytical Method Development And Validation Of Few Oncology Drugs By Using Lc-Ms-Ms. Journal of Pharmaceutical Negative Results, 16–27. https://doi.org/10.47750/pnr.2022.13.S01.03
28. Reddy, K. T. K., & Haque, M. A. (2022). Bioanalytical method development and validation of atrasentan in human plasma using verapamil as internal standard by liquid chromatography coupled with tandem mass spectrometry. International Journal of Health Sciences, 6(S8), 625–638. https://doi.org/10.53730/ijhs.v6nS8.10470
29. Konatham Teja Kumar Reddy et.al (2020). High Performance Liquid Chromatography for The Simultaneous Estimation of Anti-Ulcer Drugs in Pharmaceutical Dosage Form, journal of Positive School Psychology, Vol. 6, No. 9, 4524-452
30. Reddy KTK, Haque MA. (2022). Development and Validation of a High Throughput Lc-Ms/MS Method for Quantitation of Ipilimumab in Human Plasma. International Journal of Pharmaceutical Quality Assurance. ;13(3):303-307
31. Teja Kumar Reddy Konatham, M. Anuradha (2020), a stability indicating method development and validation of Telmisartan and Nifedipine in pure form using RP-HPLC. International Journal of Pharmaceutical, Biological and Chemical Sciences, 9(3): 36-44

32. Konatham Teja Kumar Reddy et, al (2023). bio-analytical method development and validation of cypermethrin pesticide using GC-FID method, Eur. Chem. Bull. 12(Special Issue 1), 9-19 doi: 10.31838/ecb/2023.12.sa1. 0022023.20/04/2023
33. Teja Kumar Reddy Konatham, Satyanarayana Reddy K., Anuradha Manipogo, (2020). A Review on viruses that originated from China; Sars, mers and covid-19 World Journal of Pharmaceutical Research, Vol 9, Issue 5, 2010-2015.
34. Teja Kumar Reddy Konatham et al, A Systematic Review on Method Development and Validation of Few Antiviral Drugs by Using RP-HPLC. Ijppr.Human, 2021; Vol. 21 (3): 651-661.
35. Konatham Teja Kumar Reddy and Kumaraswamy Gandla. Novel Vesicular Drug Delivery Systems Proniosomes. Pharm Res 2022, 6(3): 000272.
36. Konatham et al. synthesis and evaluation of some novel oxadiazole derivatives, World Journal of Pharmaceutical Research, Vol 9, Issue 4, 2020.
37. Baig Shahed Mirza, Haque Akiful Mohammad, Konatham Reddy Teja Kumar, Mohammad Duza Badrud, Yahya Aateka Barrawaz, Saffiruddin Sana Shaikh, Siddiqui A. Falak and Khan L. Sharuk*, Recent Advancements in Hyperthermia-Driven Controlled Drug Delivery from Nano therapeutics, Recent Advances in Drug Delivery and Formulation 2022; 16(4) . https://dx.doi.org/10.2174/2667387816666220902091043
38. Yelampalli, Suresh Reddy, Kumaraswamy Gandla, Konatham Teja Kumar Reddy, Adel Ehab Ibrahim, and Sami El Deeb. 2023. "Determination of Sodium, Potassium, and Magnesium as Sulfate Salts in Oral Preparations Using Ion Chromatography and Conductivity Detection" Separations 10, no. 2: 99. https://doi.org/10.3390 /separations10020099
39. Teja, M.; Konatham, T.; Muralidharan, V.; Murugesan, A.; Vasantha, N.; Hyandavi, M. A Review on Biosensors for COVID-19. IJAPSR 2022, 7, 9-14.
40. K. Sudheer Kumar / "Formulate and evaluate the herbal bath soap" using extracts of three plants having ethnic and dermatological importance in Ayurveda, namely Azadirecta indica, curcuma longa, ocimum tenuiaflorum "NeuroQuantology | October 2022 | volume 20 | issue 12 | page 1048-1054| doi: 10.14704/nq.2022.20.12. Nq77087
41. Kumaraswamy Gandla, *Konatham Teja Kumar Reddy, Qutaiba A. Qasim, N. Dora Babu, Manish Kumar Maity, a study of buying behavioral parten of generic drugs and branded drug, Eur. Chem. Bull. 2023,12(3), 389-400 doi: 10.31838/ecb/2023.12.3.0302023.20/04/2023
42. Deepti Kolli, Vanapalli Mohan Murali Krishna, Madhusudhana Reddy Nimmakayala, Konatham Teja Kumar Reddy, (2023). Analytical method validation for determination of % assay in pazopanib tablets 200 mg and 400 mg by HPLC, Eur. Chem. Bull. 12(3), 1522-1533 doi: 10.31838/ecb/2023.12.3.1132023.21/04/2023
43. Deepti Kolli, Yaramala Ravindrasena Reddy, Madhusudhana Reddy Nimmakayala, Konatham Teja Kumar Reddy; (2023). Method development for determination of %drug release in dissolution for afatinib tablets 20 mg and 50 mg by Rp-Hplc with PDA detector, Eur. Chem. Bull. 2(3), 1508-1521: doi: 10.31838/ecb/2023.12. 3.1122023.21/04/2023
44. Bharadhan Bose, Uttam Prasad Panigrahy, Jeetendra Kumar Gupta, Konatham Teja Kumar Reddy, Chandaka Madhu, Jeevanandham Somasundaram, Rutuja Sonawane, Chandan R S*, Anupama G (2023). Determination and quantification of cypermethrin pesticide residue in cucumber using RP-HPLC Eur. Chem. Bull. 12(4), 235-246 , doi: 10.31838/ecb/2023.12.4.0182023.21/04/2023
45. Suresh Reddy Yelampalli, Mercy Anvitha Kamireddy, Deepti Kolli, Madhusudhana Reddy Nimmakayala, B. Raj Kumar, Chandaka Madhu, Konatham Teja Kumar Reddy, (2023). Stability Indicating Analytical Method for Simultaneous Estimation of Assay of Ibuprofen, Domiphen Bromide and Related Substances of Ibuprofen in Finished Formulation by UPLC Eur. Chem. Bull. 51-871, doi: 10.31838/ecb/2023.12.si4.0812023.22/04/202

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