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Advances in Bioresearch

Unlocking The Therapeutic Potential of Quinazoline and Quinazolinone Derivatives: A Review of their Anticancer Properties

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ABSTRACT
This review explores the potential of quinazoline and quinazolinone derivatives as anticancer agents. These heterocyclic compounds have shown diverse biological activities, including potent cytotoxic and antiproliferative effects against various cancer cell lines. Numerous studies have synthesized novel quinazoline and quinazolinone derivatives and evaluated their anticancer properties. Many compounds demonstrated superior activity compared to standard chemotherapeutic drugs against breast, lung, prostate, and colon cancer cells. Structure-activity relationship analyses revealed key structural features enhancing anticancer potency. Several derivatives exhibited promising inhibitory activity against important cancer targets like EGFR, VEGFR, and PI3K. Molecular docking studies provided insights into binding modes with target proteins. Anticancer mechanisms included induction of apoptosis, cell cycle arrest, and inhibition of cell migration. Some compounds showed selectivity for cancer cells over normal cells, indicating potential for reduced side effects. While further research is needed, this review highlights the therapeutic promise of quinazoline and quinazolinone scaffolds for developing novel, potent anticancer drugs with potentially improved safety profiles.
Keywords: Quinazoline, quinazolinone, therapeutic agents, cancer therapy and anticancer agents.

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INTRODUCTION

Medicinal chemistry is concern with the discovery, development, and synthesis of the target compounds in the laboratory and identification of the physical and chemical properties, which are followed by the evolution of the drug characteristics. The fused heterocycle classes quinazolines and quinazolinones are of tremendous interest because of the vast range of biological features they possess [1]. Numerous substituted Quinazoline and Quinazolinone derivatives have a variety of biological activities, including weedicide, muscle relaxant, antitubercular, antidepressant, anticonvulsant, antimalarial, anticancer [2], antimicrobial, antifungal, antiviral, antiprotozoan, anti-inflammatory, diuretic, and many more (Figure 1)[3]. Quinazoline and Quinazolinone chemicals are also found in many medicinal molecules and are utilized in the synthesis of several functional materials for synthetic chemistry (Figure 2). This review focuses on the diverse biological actions of quinazolines and quinazolinones in an effort to broaden their enormous potential [4]. In recent years, quinazolines and quinazolinones have emerged as promising scaffolds for the development of novel therapeutic agents. The synthesis of these compounds has been extensively studied and various methods have been developed to access these heterocycles. This has led to the discovery of numerous quinazoline and quinazolinone derivatives with potent biological activities.
Cancer is a multifactorial disease known as the uncontrolled growth of abnormal cells in a body that can infiltrate and destroy normal body tissue [5]. cancer is expected to be one of the leading causes of death,

affecting the lives of millions of people around the world [6,7]. There are six common hallmarks of cancer: sustaining proliferative signaling, evading growth suppression, resisting cell death, enabling replicative immortality, including angiogenisis, and activating invasion and metastasis [8,9].

This review aims to provide a comprehensive overview of the chemistry and biology of quinazolines and quinazolinones, with a focus on their anticancer properties [10,11]. We will discuss the synthesis, structure-activity relationships, and pharmacological activities of these compounds, highlighting their potential as therapeutic agents for the treatment of cancer.

Figure 1: Pharmacological activities of Quinazoline and Quinazolinone

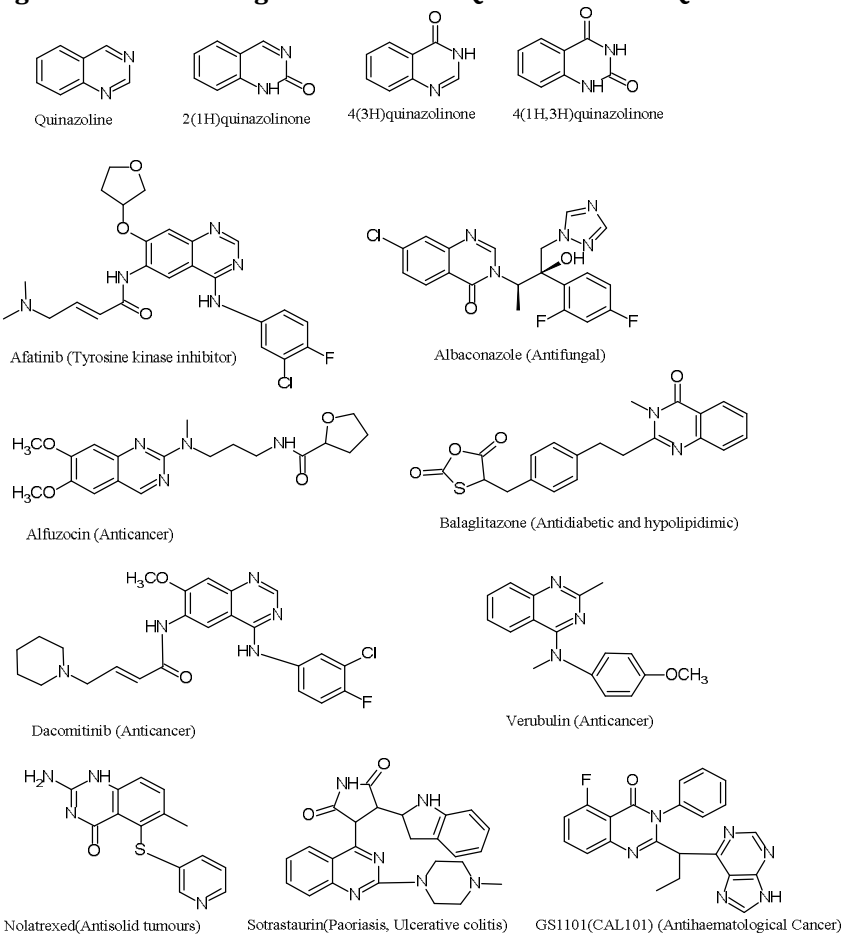
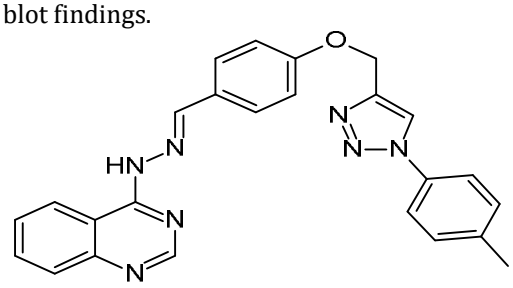


Figure 2: Some marketed available drugs contain quinazoline and quinazolinone moiety

QUINAZOLINE AS CYTOTOXIC AGENTS

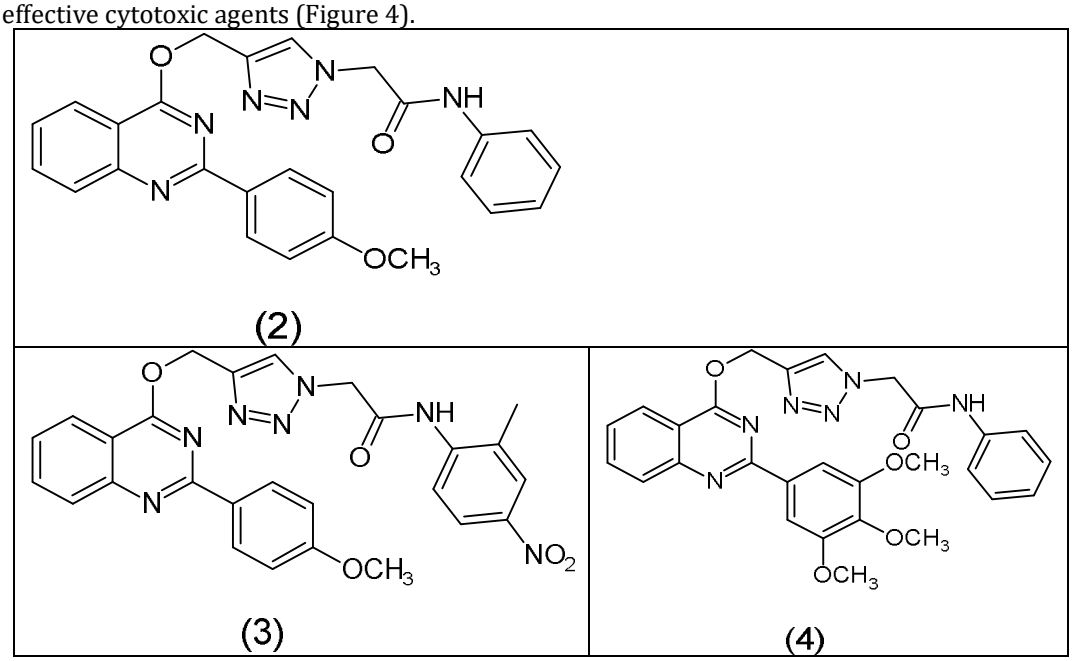
Mortazavi, Motahareh, et al. [12] created and produced a novel class of 1,2,3-triazole-containing quinazoline derivatives as specific anticancer drugs. The antiproliferative effects of synthetic compounds against 6 cancer cell lines from different origins, including MET-dependent AsPC-1, EBC-1, and MKN-45 cells, and also Mia-Paca-2, HT-29, and K562 cells. Compound 1 (Figure 3) bearing a p-methyl benzyl moiety on the triazole ring exhibited the highest MET inhibitory capacity among tested agents, which was further confirmed by western blot findings.



(1)

Figure 3: p-methyl benzyl moiety on the triazole ring

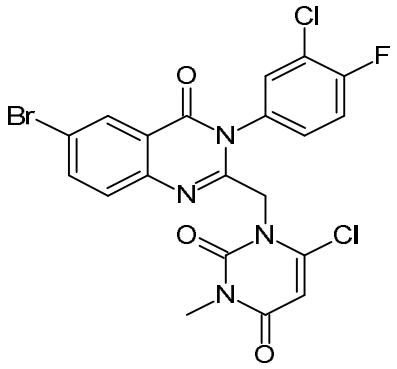
Pedrood, Keyvan, et al. [13] created a new class of quinazoline-based compounds with triazole-acetamides and evaluated there in vitro cytotoxic effects on three human cancer cell lines (HCT-116, MCF-7, and HepG2) as well as a normal cell line (WRL-68). Compound 2 was the most effective derivative against HCT-116, HepG2, and cytotoxic study against MCF-7 revealed that compounds 2, 3, and 4 are the most effective cytotoxic agents (Figure 4).



(2) (3) (4)

Figure 4: The most effective cytotoxic agents

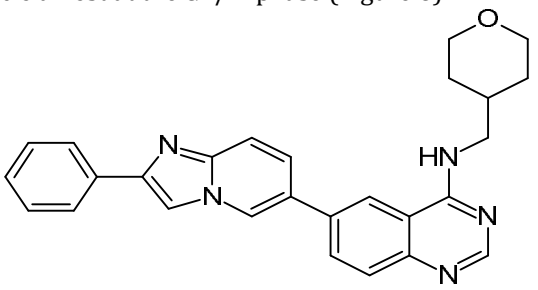
Zare, Somayeh, et al. [14] designed and synthesized some new quinazoline-pyrimidine hybrid derivatives. The antiproliferative activities were examined against a panel of three human cancer cell lines: A549, SW-480, and MCF-7. Compound 5 showed the highest antiproliferative activities against the tested cell lines. The results indicated that compound 5 could induce apoptosis in the A549 cell line in a dose-dependent manner and arrest in the S phase of the cell cycle (Figure 5).



(5)

Figure 5: Chemical Structure of compound 5

Li, Mei, et al. [15] a number of novel 6-(imidazo[1,2-a]pyridin-6-yl)quinazoline derivatives that shown submicromolar inhibitory efficacy against different tumor cell lines were designed, produced, and characterized. Compound 6 demonstrated potent PI3Kα inhibitory action, which caused HCC827 cells to undergo cell death and cell cycle arrest at the G2/M phase (Figure 6).



(6)

Figure 6: Chemical Structure of compound 6

Oleiwi, Mohammed Abdulameer, and Munaf H. Zalzala [16] synthesized and characterized New 4(3H)-quinazolinone derivatives and evaluated for cytotoxic activity against a set of human cancer cell lines, MCF-7 (breast) and A549 (lung). All tested compounds displayed higher cytotoxicity against the cancer cell line among all tested compounds, compound 7 and 8 exhibited the highest cytotoxic activity against the breast cancer cell line (MCF-7) and lung cancer cell line (A549) compared to Methotrexate (MTX) as a positive control (Figure 7). A molecular docking study showed that both compounds 7 and 8 displayed partially a similar binding mode with the active site of DHFR in comparison with the co-crystallized ligand (MTX), whereas compound 7 showed a different binding mode with the active site of thymidylate synthase when compared with the co-crystallized ligand (raltitrexed).

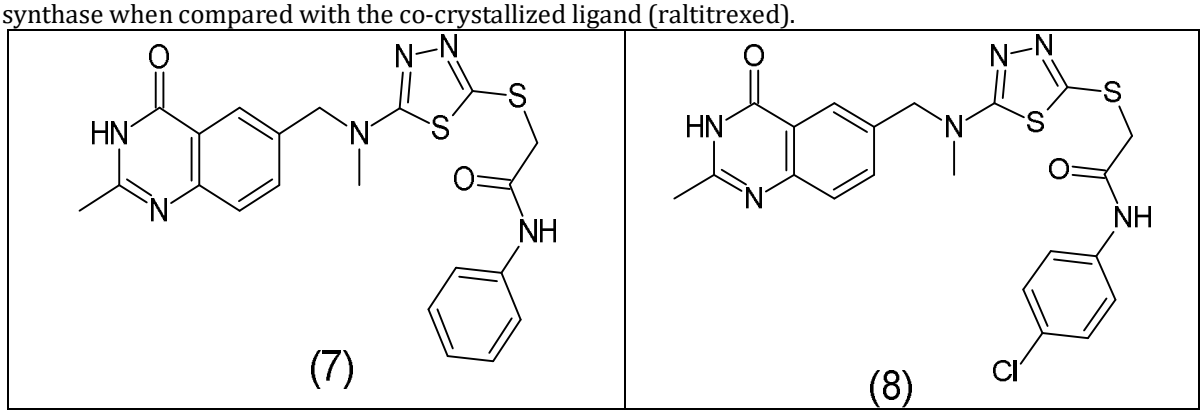
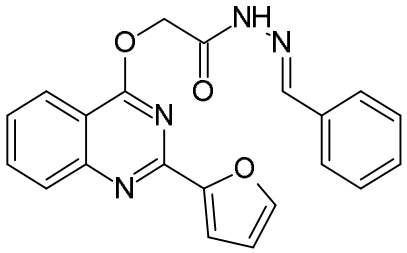


Figure 7: Chemical Structure of compound 7 and 8

Ahmed, Marwa F., Amany S. Khalifa, and Emad M. Eed [17] synthesized novel quinazoline derivatives containing a fuoryl moiety and evaluated their antiproliferative activity against a human breast cancer cell line (MCF-7) and a colon cancer cell line (HCT116) using the sulphorhodamine-B assay technique

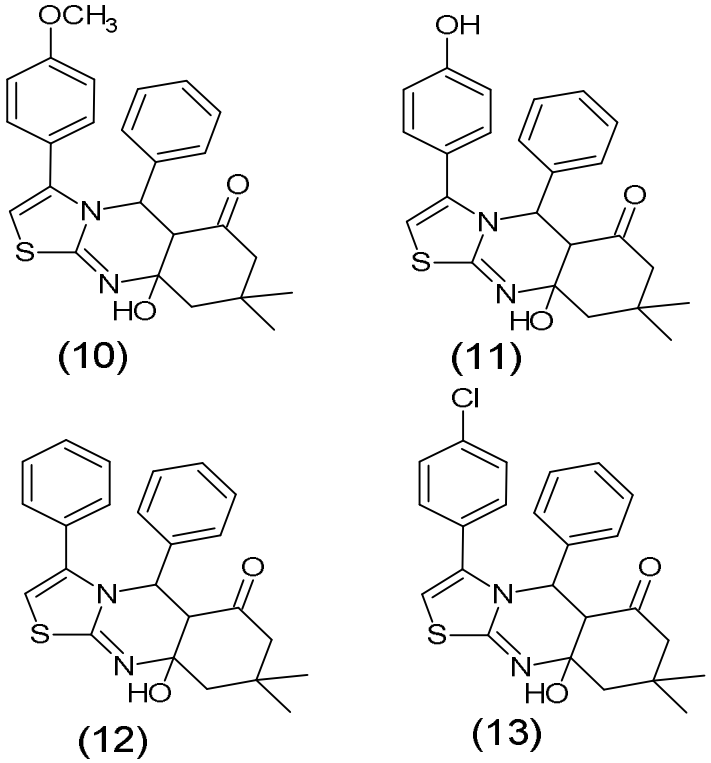
[18]. Compound 9 is the most effective against both cancer cell lines compared with Doxorubicin as positive control (Figure 8).



(9)

Figure 8: Chemical Structure of compound 9

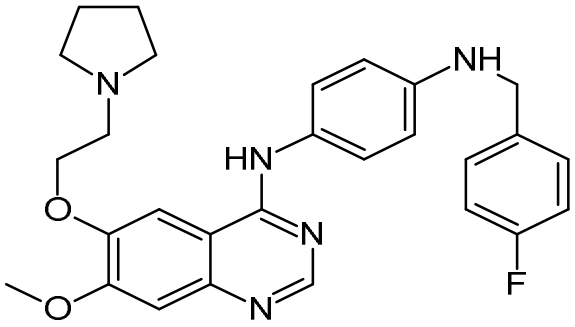
Mir, Showkat Ahmad, et al. [19] Create new molecular scaffolds that block EGFR-TKD with few adverse effects, then use in vitro cell models to assess their potential as an anticancer medication. Using molecular docking, the binding energy of thiazole-[2,3-b] quinazolinone derivatives to EGFR-TKD was ascertained and contrasted with that of erlotinib, the positive control. Molecular docking research revealed that compounds 10 to 13 exhibited greater bindings than noscapine and erlotinib. The anti-cancer effects of the compounds were assessed using an experimental cell proliferation test on Hep-G2 and MCF-7 cancer cell lines. Compound 12 demonstrated the most anticancer effect against Hep-G2, whereas compound 11 showed encouraging anticancer activity against MCF-7. The chemical structure of compound from 10-13 are shown in Figure 9.



(10) (11) (12) (13)

Figure 9: Chemical Structure of compound 10-13.

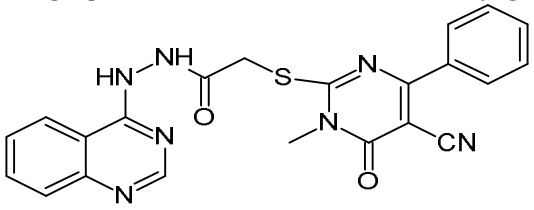
Pan, Jing, et al. [20] A number of new 4-amino quinazoline derivatives were created and synthesized, and their biological activity against breast cancer using the NF-κb pathway was assessed. Of them, Compound 14 showed strong inhibition in the cell lines SK-BR-3 and HCC1806. The possible binding mechanism between Compound 14 and the important NF-κb pathway proteins p65 and IkBα was also depicted by the molecular docking experiments (Figure 10).



(14)

Figure 10: Chemical Structure of compound 14.

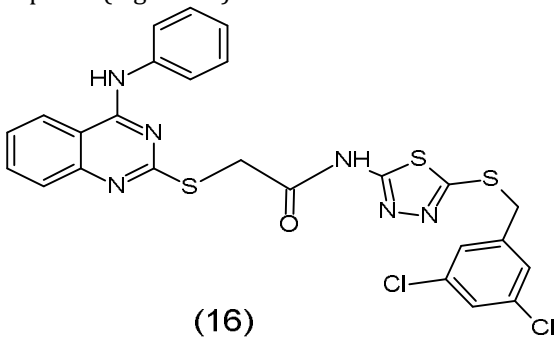
Said, Eman G., et al. [21] designed, and synthesized a series of 4-amino quinazolines linked to cyanopyrimidine derivatives and screened for their anticancer activities. Compound 15 showed valuable apoptotic activity toward tumor cells in UO-31, MCF-7, and IGROV-1 cell lines. Compound 15 exhibited good EGFR, CDK-2, and TS inhibition activity in comparison to references lapatinib, ribociclib, and 5-fluorouracil. The molecular modeling for compound 15 inside the ATP binding site of epidermal growth factor receptor and cyclin-dependent kinase-2 enzymes was performed to predict the binding mode to the active site of these enzymes using lapatinib and ribociclib as standard (Figure 11).



(15)

Figure 11: Chemical Structure of compound 15.

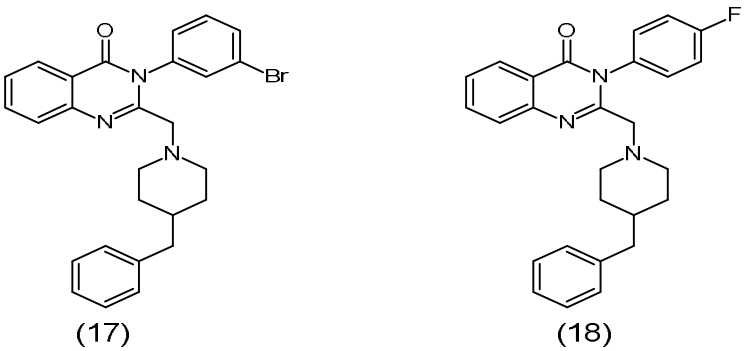
Si, Xiaojie, et al. [22] The antiproliferative qualities of several novel 4-amino quinazoline derivatives containing 1,3,4-thiadiazole were evaluated using the four human cancer cell lines H1975, PC-3, MCF-7, and HGC-27. Compound 16 showed high anti-tumor growth efficiency against four tested cancer cell lines when compared to the reference drug gefitinib. Compound 16 may inhibit PC-3 cell migration and cloning by stopping the cell cycle in the S phase (Figure 12).



(16)

Figure 12: Chemical Structure of compound 16.

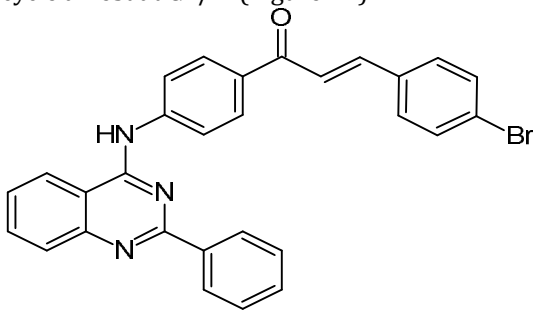
Emami, Leila, et al. [23] synthesized a series of quinazolinone-benzyl piperidine derivatives as antiproliferative agents. Compound 17 showed potent activity against cancerous cell lines MCF-7, A549, and 5367, compared to cisplatin as a reference drug. Molecular docking results also supported the cytotoxic activities of compounds 17 and 18 as EGFR inhibitors (Figure 13).



(17) (18)

Figure 13: Chemical Structure of compound 17 and 18.

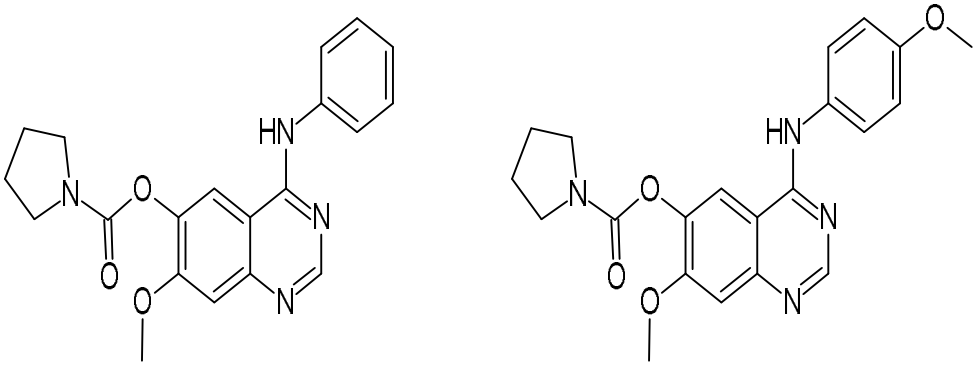
Niu, Zhenxi, et al. [24] A new series of quinazoline compounds was created and synthesized, and their broad-spectrum anticancer efficacy against MGC-803, MCF-7, PC-9, A549, and H1975 was subsequently assessed. Compound 19 demonstrated specific inhibitory action against MGC-803 at the nanomolar level. Compound 19 reduced the proportion of MGC-803 cells in the G1 phase in a dose-dependent manner while significantly inducing cell cycle arrest at G2/M (Figure 14).



(19)

Figure 14: Chemical Structure of compound 19.

Han, Xiao, et al. [25] synthesized a series of novel 4-arylaminoquinazoline derivatives, and the structure of compound 20 was analyzed by single-crystal X-ray diffraction. The antitumor activity of compound 21 was evaluated on A549 and H1975 and showed a good inhibitory effect on cell line A549 and cell line H1975, which is better than the positive control drug Zorifertinib against A549 and H1975. The molecular docking of compound 21 with $EGFR^{WT}$ and $EGFR^{L858R/T790M}$ showed better inhibitory activity by hydrogen bonding, and ADME prediction indicated that compounds had good physical and chemical parameters. The chemical structure of compound 20 and 21 are shown in Figure 15.



(20) (21)

Figure 15: Chemical Structure of compound 20 and 21.

Qin, Xuemei, et al. [26] developed and produced several quinazoline derivatives, and the cytotoxic potential of the newly produced compounds was tested using the human kidney epithelium T293 cell line, normal lung cell lines WI-38, non-small cell lung cancer A549, and NCI-H157 cell lines. Compounds 22, 23,

23, 24, 25, 26, 27, and 28 were the most potent anticancer medications against EGFR kinase (Figure 16). A docking study found that compound 22 may readily bind to the EGFR's ATP binding site.

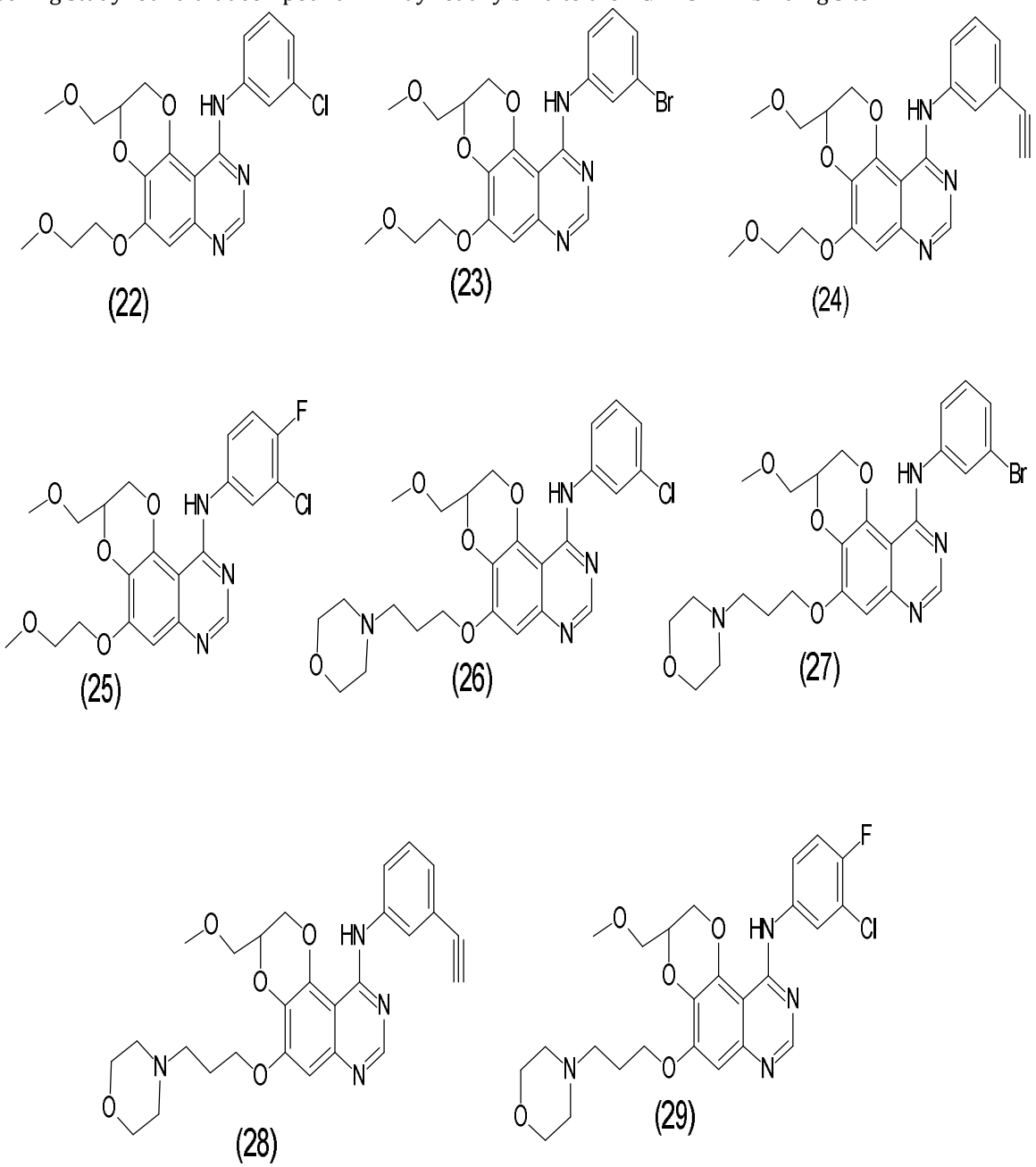


Figure 16: Chemical Structure of compound 22-29.

El-Adl, Khaled, et al. [27] Quinazoline derivatives were created and synthesized, and they were subsequently evaluated against HepG2 and HCT-116. Compounds 30, 31, 32, 33, 34, 35, 36, 37, and 38 shown potent anti-proliferative activity against HepG2 and HCT-116 cell lines when contrasted with doxorubicin as a positive control (Figure 17). The strongest anti-proliferative substances exhibited very strong to moderate DNA-binding affinities.

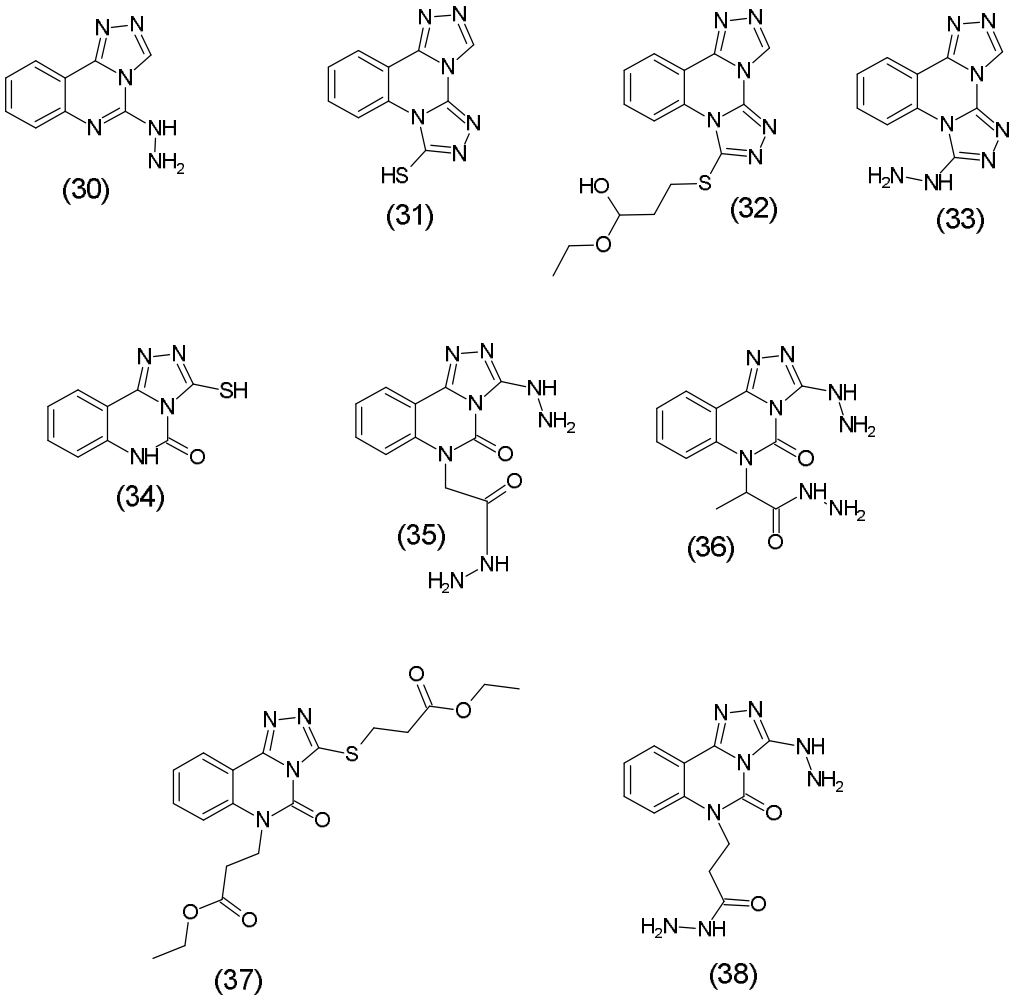


Figure 17: Chemical Structure of compound 30-38.

Emami, Leila, et al. [28] Produced a number of derivatives of quinazolines and Cytotoxic effects were assessed in vitro against the A549, MCF-7, and SW1116 human cancer cell lines. On the A549 cell line, compounds 39, 40, and 41 had favorable anticancer activity when compared to cisplatin, a reference medication (Figure 18). These drugs' molecular docking investigations on EGFR verified that the anticancer activity and docking studies have a strong association.

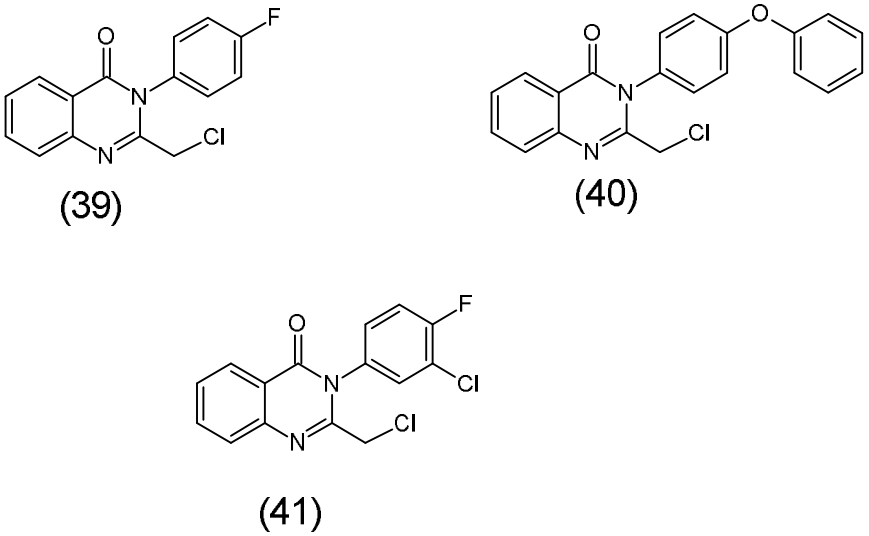
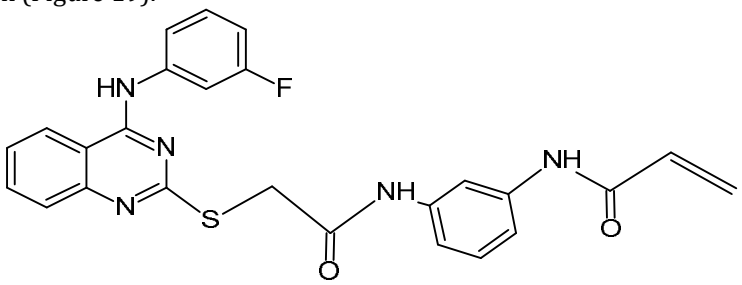


Figure 18: Chemical Structure of compound 39-41.

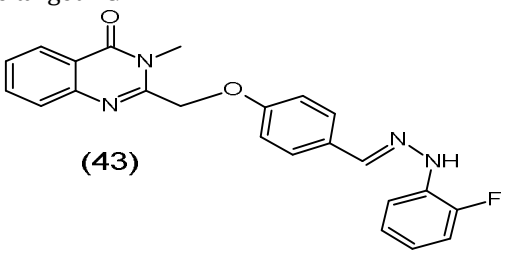
Wang, Zhengjie, et al. [29] A number of new 4-amino quinazoline derivatives with N-phenylacetamide were created and synthesized, and their anticancer properties were assessed against the human cancer cell lines H1975, PC-3, MDA-MB-231, and MGC-803. When compared to the reference medication, gefitinib, compound 42 had the most antiproliferative action against these cell lines. Compound 42's molecular docking studies on EGFR kinase verified that the anticancer activities and the docking studies had a strong association (Figure 19).



(42)

Figure 19: Chemical Structure of compound 42.

Shao, Li-Hui, et al. [30] designed, and synthesized three series of quinazolinone derivatives containing hydrazone structures and evaluated them for antitumor activities toward human lung cancer cells (A549) and human prostate cancer cells (PC-3). Compound 43 showed potent inhibitory activity towards A549 and PC-3 compared to Gefitinib and 5-Fluorouracil as reference drugs (Figure 20). The 3D-QSAR model was constructed via the comparative molecular field analysis (CoMFA) model. Compound 43 was well-docked into the binding site of the target EGFR.



(43)

Figure 20: Chemical Structure of compound 43.

Aziz, Marian W., et al. [31] To develop and produce a novel family of Quinazolinone derivatives and assess their cytotoxic activity against MCF-7 and A549 cell lines in conjunction with their flagship medications, erlotinib and gefitinib. Compounds 44, 45, 46, 47, and 48 showed strong cytotoxic effects on the MCF-7 and A549 cell lines (Figure 21). The sub-molecular action of compounds 45 and 46 was rather robust in comparison to that of erlotinib and gefitinib. Compounds 45 and 46 produced pre-G1 apoptosis and cell cycle arrest at the G2/M phase. The results of pharmacophore and molecular docking studies showed that the fitting and the binding mechanism matched the EGFR inhibitory activities of drugs 45 and 46.

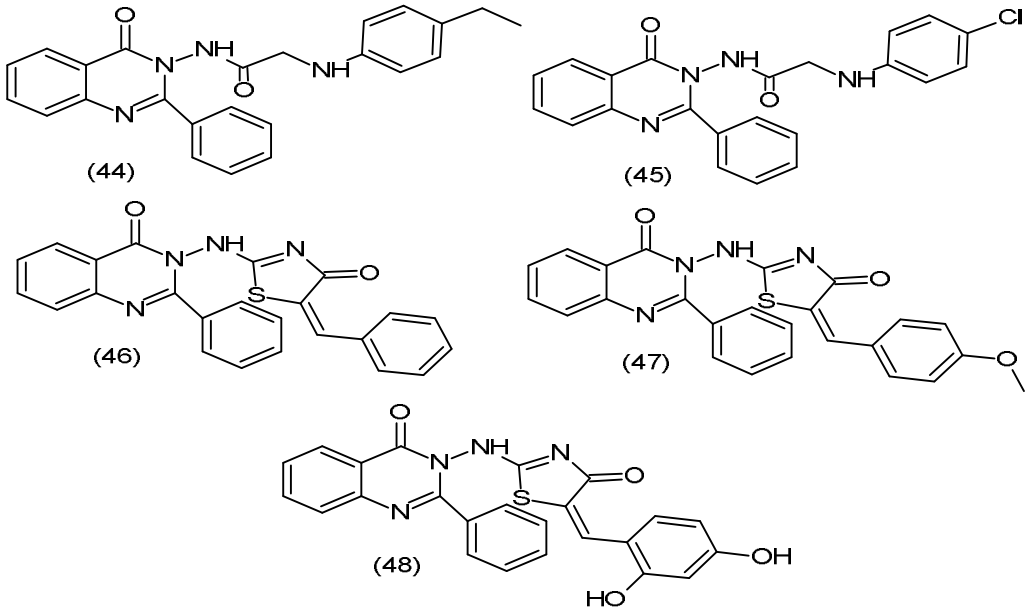


Figure 21: Chemical Structure of compound 44-48.

Zhang, Bin, et al. [32] produced a number of derivatives of quinazolines and Cytotoxic effects were assessed in vitro against the A549, MCF-7, and SW1116 human cancer cell lines. On the A549 cell line, compounds 39, 40, and 41 had favorable anticancer activity when compared to cisplatin, a reference medication (Figure 22). These drugs' molecular docking investigations on EGFR verified that the anticancer activity and docking studies have a strong association. Mechanism investigations revealed that under hypoxic conditions, compound 49 inhibits the expression of CAIX and its upstream HIF-1α in H1975 cells. Using molecular docking assays, the binding pattern of compound 49 with the proteins $EGFR^{WT}$, $EGFR^{T790M}$, and CAIX was shown.

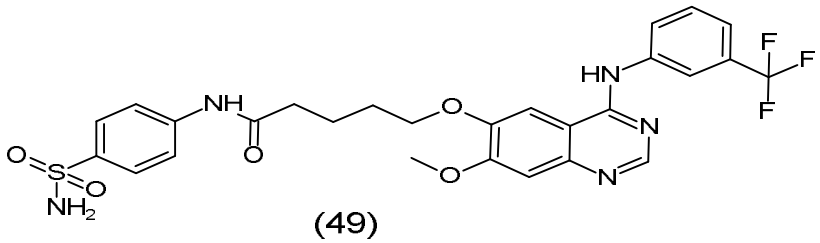


Figure 22: Chemical Structure of compound 49.

Wei, Xin-Wei, et al. [33] synthesized a series of 2-Styryl-4-aminoquinazoline derivatives as antitumor agents and their cytotoxicities against four cancer cell lines with different p-53 status, including bladder cell T24 (w-p53), gastric cell MGC-803 (m-p53), prostate cell DU145 (m-p53), prostate cell PC-3 (null-p53), lung cell A549 (w-p53), and normal liver cell line HL-7702 (w-p53) were examined. Compounds 50, 51, 52, 53, 53, and 54 exhibited especially potent cytotoxicity, and compound 50 displayed exceptional efficacy against MGC-803 and T24 cancer cell lines (Figure 23). Epirubicin and CP-31398 were used as the positive control.

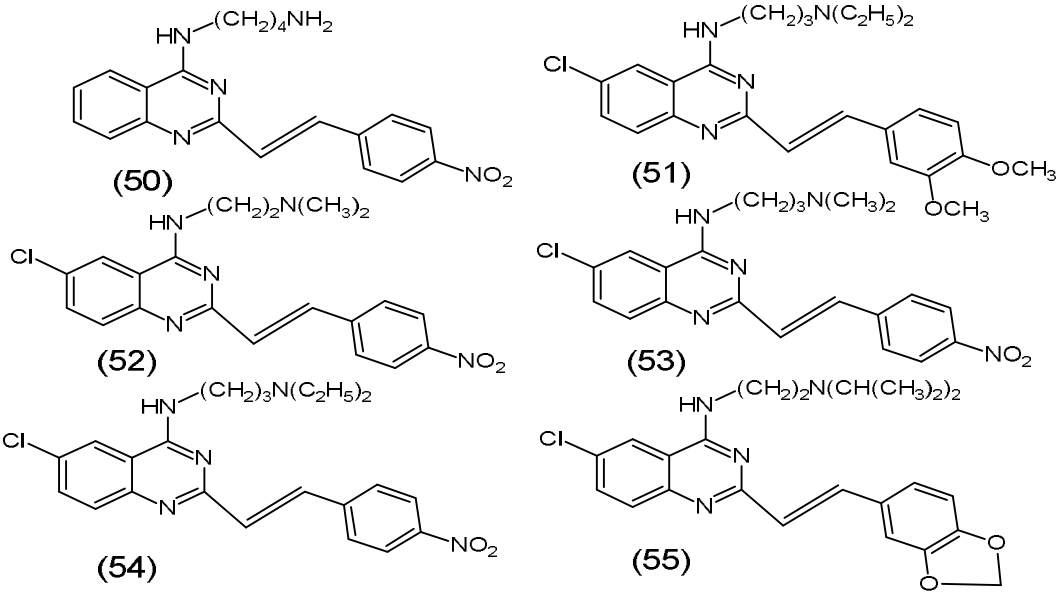


Figure 23: Chemical Structure of compound 50-55.

Pedrood, Keyvan, et al. [33] produced new quinozolinone compounds and tested them against human carbonic anhydrase I and II, acetylcholinesterase, butyrylcholinesterase, and α-glycosidase, which are metabolic enzymes. Compared to the conventional inhibitor acetazolamide, compounds 59 and 57 demonstrated stronger inhibitory actions against human carbonic anhydrase I and II. Compared to the conventional inhibitor tacrine, compounds 61, 60, and 57 demonstrated stronger inhibitory actions against acetylcholinesterase and butyrylcholinesterase. Compared to the conventional inhibitor acarbose, compounds 58, 59, 56, and 57 had considerable inhibitory actions against α-glycosidase (Figure 24). These powerful substances were docked into the active site of these enzymes using molecular docking techniques.

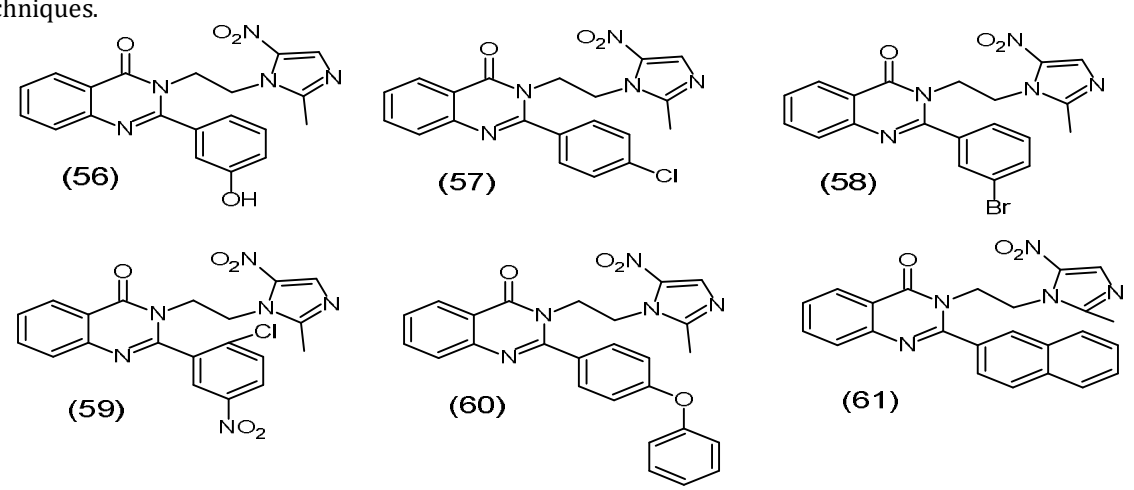


Figure 24: Chemical Structure of compound 56-61.

Khazir, Jabeena, et al. [34] Many quinazoline sulphonyl acetamide analogs were created and produced against human cancer cell lines, including SF268 (CNS), MCF-7 (breast), PC-3 (prostate), and HCT-1 and HT-15 (colon). After that, their cytotoxic activity in vitro was assessed. It was discovered that compounds 62, 63, and 64 had stronger anticancer properties than the commonly used medications mitomycin and Adriamycin (Figure 25).

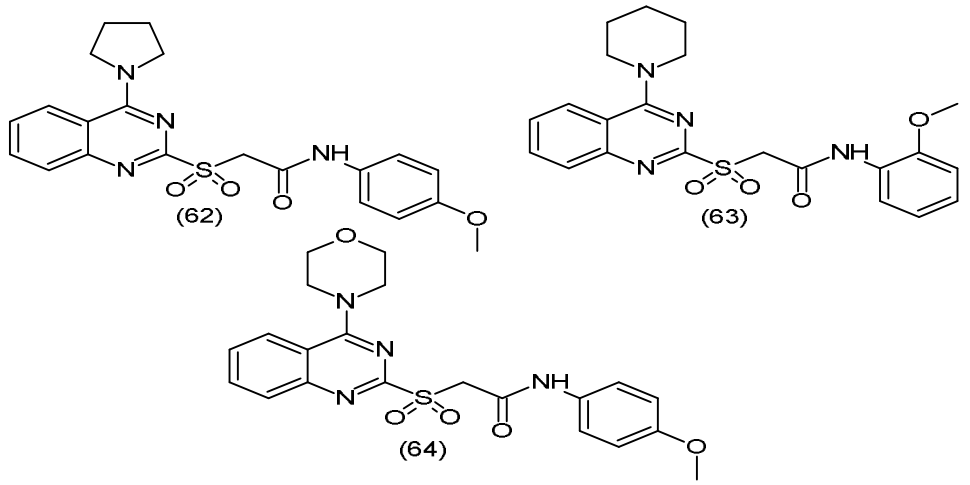


Figure 25: Chemical Structure of compound 63 and 64.

Le, Yi, et al. [35] designed and synthesized a series of novel 3-methyl quinazolinone derivatives and evaluated them for in vitro antitumor activity against three kinds of human tumor cell lines: PC-3, SMMC-7721, and A549. Compounds 65, 66, and 67 have good inhibition against $EGFR^{wt}$-TK (Figure 26). Compounds 66 and 67 exhibited superior biological activities, then gefitinib and 5-fluorouracil as positive controls. Molecular docking, molecular dynamics simulation, and MM/GBSA estimation Illustrated possible binding modes of these compounds with EGFR.

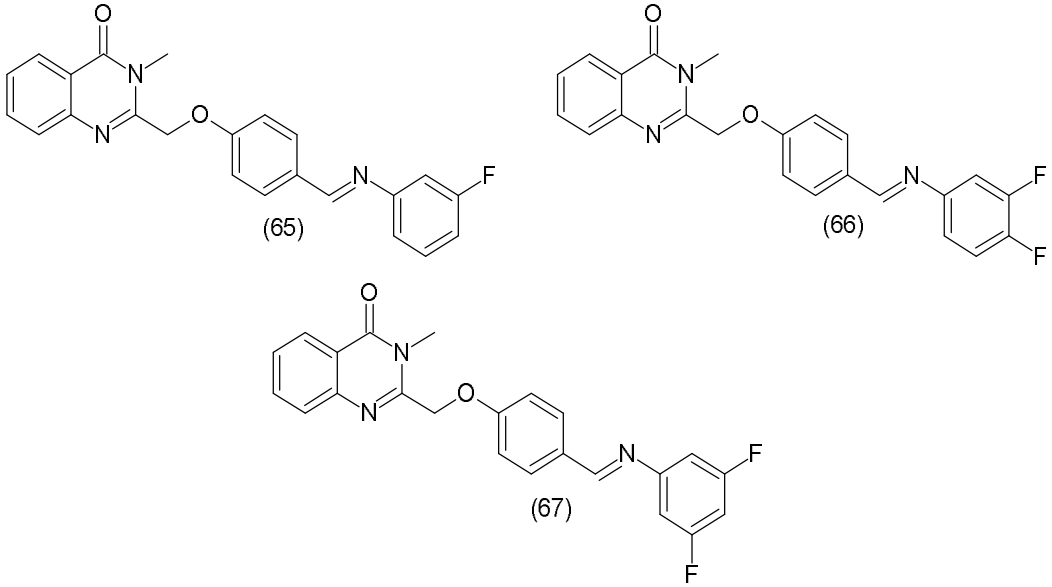


Figure 26: Chemical Structure of compound 65-67.

Noser, Ahmed A., et al. [36] synthesized novel quinazolinone derivatives, and quinazoline analogs were described as potential anticancer agents targeting AKT1 protein. Compounds 68 and 69 exhibited significant cytotoxic activity against Caco-2, HepG2, and MCF-7 cancer cells. Compound 68 had more significant inhibitory effects than compound 69 on Caco-2, HepG2, and MCF-7 cell lines when compared to Doxorubicin as a reference drug (Figure 27).

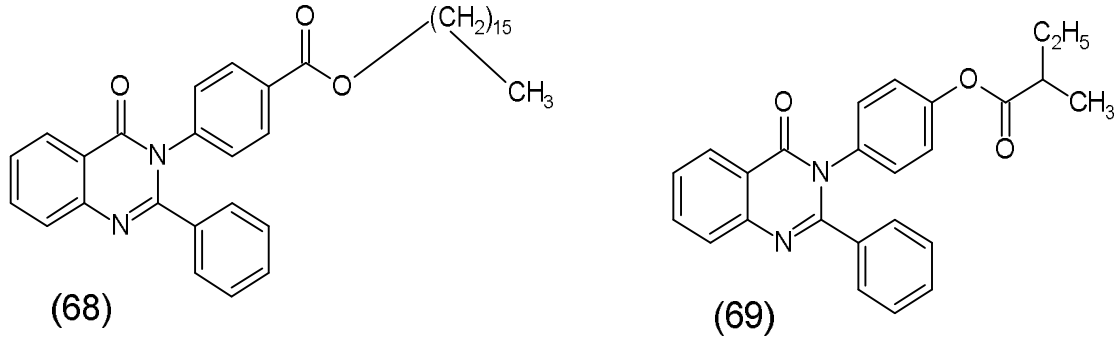


Figure 27: Chemical Structure of compound 68-69.

Emami, Leila, et al. [37] Using spectroscopic techniques, a novel series of quinazolinone-pyrimidine hybrids was created and synthesized. Their inhibitory action against Dipeptidyl peptidase-4 (DPP-4) was assessed. The most effective derivative with a cytotoxic impact and DPP-4 inhibitory action was compound 70, which had a 4-phenoxy moiety on the phenyl ring at position 3 of the quinazolinone scaffold. According to the SAR investigations, the DPP-4 inhibitory action was enhanced when a bulky substituent or an electron-withdrawing group on the phenyl ring was swapped out for an electron-donating group, especially on the colorectal cancer HT-29 and SW1116 cell lines. When compared to cisplatin and sitagliptin, compound 70 was the most effective (Figure 28).

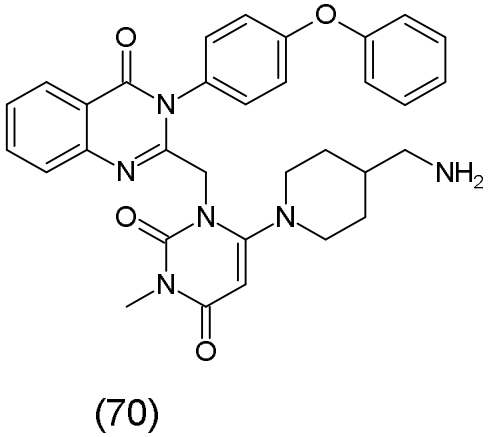


Figure 28: Chemical Structure of compound 70.

Ramadan, Sayed K. et al. [38] Using a microwave, a new class of ecologically friendly quinazolinone-based chemicals was developed as potential PARP-1 inhibitors. The 4-quinazolinone scaffold was bioisostered to the phthalazinone core of the reference molecule Olaparib. Compound 71 demonstrated an inhibitory effect on PARP-1 that was comparable to that of olaparib (Figure 29).

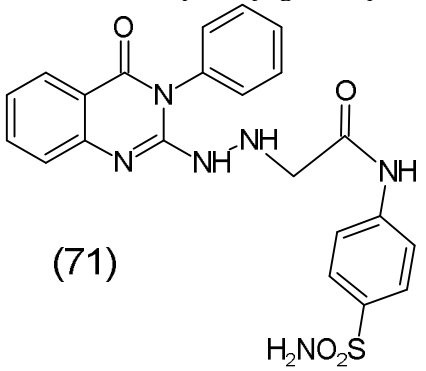


Figure 29: Chemical Structure of compound 71.

Allam, Heba Abdelrasheed, et al. [39] synthesized 6-bromo-2-(pyridine-3-yl)-4-substituted quinazoline compounds eliciting superior EGFR inhibitory activity were further screened for their in vitro cytotoxicity against two human cancer cell lines, namely: MCF7 (breast) and A549 (lung), with gefitinib as a reference.

The majority of the tested compounds showed selective anticancer activity against MCF-7 rather than the A549 cell line. Compound 72 possessed the most active EGFR inhibitor (Figure 30).

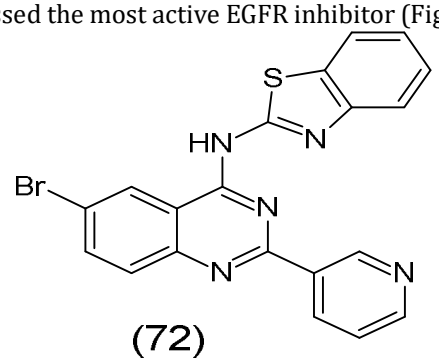


Figure 30: Chemical Structure of compound 72.

Syed, Tasqeeruddin, et al. [40] designed, synthesized, and characterized structurally modified aryl quinazoline-isoxazole derivatives and evaluated them for anticancer applications against four human cancer cell lines, including PC3, DU-145 (prostate cancer), A549 (lung cancer), and MCF-7 (breast cancer). The results were compared with etoposide, which was used as a positive control. Compounds 73, 74, 75, 76, and 77 exhibited more potent anticancer activities against the four cancer cell lines (Figure 31).

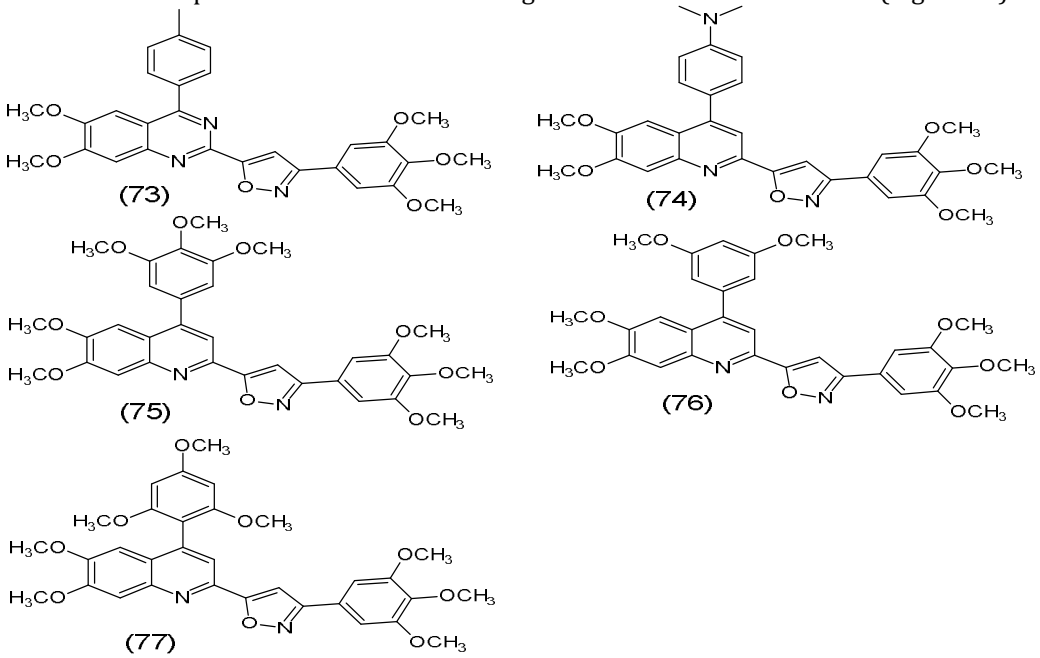


Figure 31: Chemical Structure of compound 73-77.

Fan, Haoru, et al [41] designed twelve 2,3-dihydro-[1,4]-dioxino[2,3-f] quinazoline derivatives and evaluated as vascular endothelial growth factor receptor 2 (VEGFR-2) inhibitors. Compound 78 revealed good inhibitory activity on HUVECs and low cytotoxicity compared with Lenvatinib as a positive control. A molecular docking study showed compound 78 and Lenvatinib have similar bonding sites to VEGFR-2 (Figure 32).

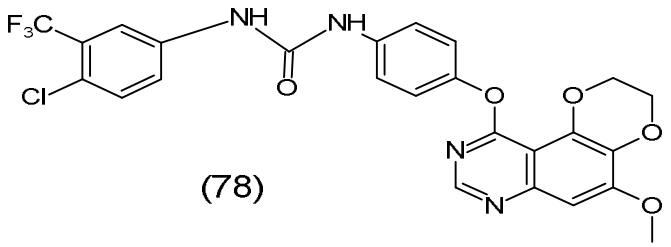


Figure 32: Chemical Structure of compound 78.

M. Srinivas, et al. [42] A number of new 1,2,4-oxadiazole-isoxazole linked quinazoline compounds were created and synthesized, and their anticancer properties were evaluated using four human cancer cell lines: MDA MB-231 (breast), A549 (lung), DU-145 (prostate), and MCF-7 (breast). Compared to etoposide as a positive reference, compounds 79, 80, 81, 82, and 83 showed increased activity on four cell lines (Figure 33). According to this molecule's structure-activity relationship (SAR) investigations, compounds 79 and 83 exhibited strong activity on four cell lines.

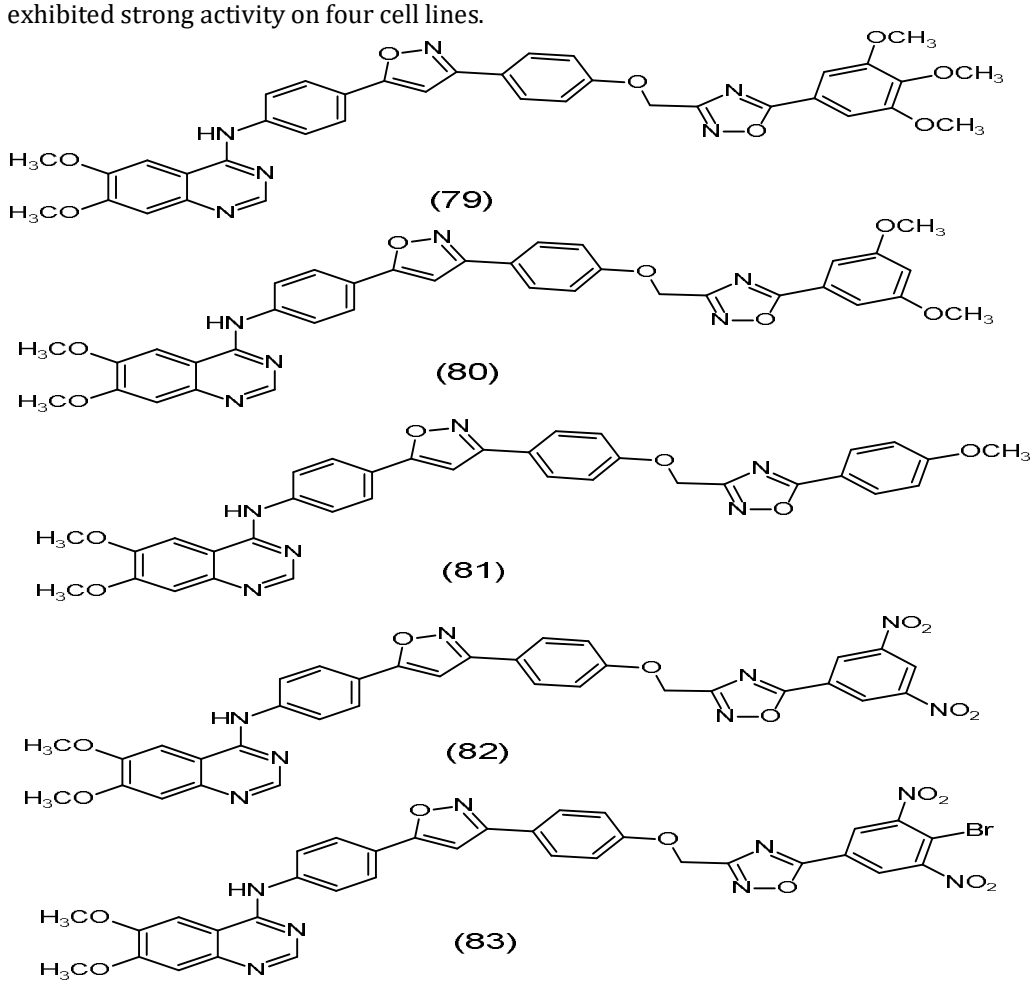


Figure 33: Chemical Structure of compound 79-83.

Alkahtani Hamad M., et al. [43] designed a new series of 2-[(3-(4-sulfamoylphenethyl)-4(3H)-quinazolinone-2-yl)thio]anilide derivatives and tested them against the human fibroblast cell line, MRC-5, as well as breast adenocarcinoma (MCF-7), colorectal adenocarcinoma (HT-29), and acute myeloid leukemia (HL-60 and K562) human cancer cell lines. In comparison to the usual medication sorafenib, compounds 84, 85, 86, 87, and 88 shown strong cytotoxic action against MCF-7, HT-29, and HL60 cells. Compared to MRC-5, compounds 84, 85, 86, 87, and 88 showed selectivity for the cancer cell lines (Figure 34). Comparing these substances to the common medication sorafenib, they likewise demonstrated strong inhibitory effect against EGFR and HER2 kinases. Compounds 84, 87, and 88 demonstrated potent VEGFR2 inhibitory action.

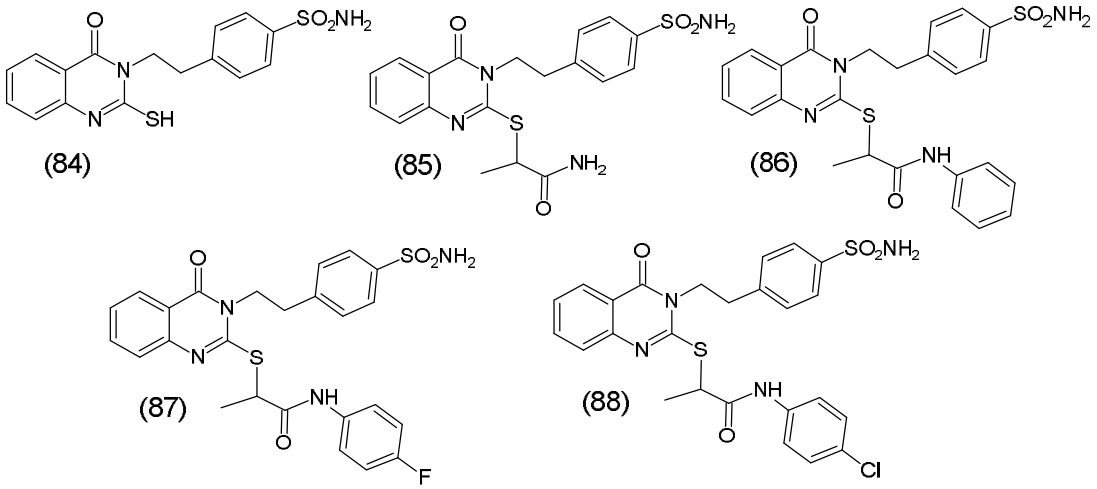
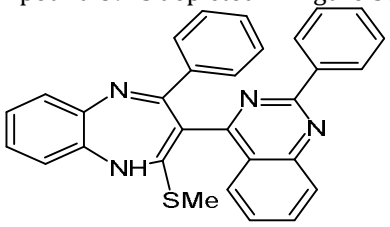


Figure 34: Chemical Structure of compound 84-88.

Misra Apoorva et al. [44] synthesized quinazoline derivatives by a one-pot domino approach in an eco-friendly manner to prepare potentially bioactive quinazoline derivatives of 1, 5-benzodiazepines. The synthesized compounds demonstrated strong cytotoxic properties against breast cancer cell line MCF-7 of humans [45]. Cell cycle distribution and caspase 3 assay study showed that compound 89 causes arrest of MCF-7 cells in the S and G2 phase probably via activation of the mitochondrial caspases cell death pathway. The chemical structure of compound 89 is depicted in Figure 35.



(89)

Figure 35: Chemical Structure of compound 89.

CONCLUSION

This comprehensive review highlights the significant potential of quinazoline and quinazolinone derivatives as anticancer agents. Numerous studies have demonstrated the potent cytotoxic and antiproliferative effects of these compounds against a wide range of cancer cell lines, including breast, lung, prostate, and colon cancers. Many of the synthesized derivatives showed superior activity compared to standard chemotherapeutic drugs. Structure-activity relationship analyses revealed key structural features that enhance anticancer potency, such as specific substituents on the quinazoline core. Several compounds exhibited promising inhibitory activity against important cancer targets like EGFR, VEGFR, and PI3K. Molecular docking studies provided insights into binding modes and interactions with target proteins. The anticancer mechanisms of active compounds included induction of apoptosis, cell cycle arrest, and inhibition of cell migration. Some derivatives also showed selectivity for cancer cells over normal cells, indicating potential for reduced side effects. While further preclinical and clinical studies are needed, this review underscores the therapeutic promise of quinazoline and quinazolinone scaffolds for developing novel, potent, and potentially safer anticancer drugs. Continued research in this area may lead to improved treatment options for various cancers in the future.

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